A DYNAMIC PLANNING MODEL FOR SMALL FARM DEVELOPMENT: SOME APPLICATIONS IN THE AZUA PLAIN, DOMINICAN REPUBLIC

By

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Important development issues facing small farmers in the Azua plain are problems of low output, low income and malnutrition. One promising approach to raising output and productivity levels is by improving the efficiency of resource allocation at the small farm level.

The man-land relationship concept is used to build a dynamic linear programming model to analyze behavioral patterns within three small farm categories. Optimum land use, production, consumption and the marketing program are determined endogenously subject to a set of production constraints and nutrient requirements. Farm-level units are aggregated to draw conclusions at the regional scale. Two objective functions are used to maximize net revenue and total output.

The study's major practical concern is to prescribe the land use pattern that yields maximum farm revenue after meeting certain household nutritional requirements. Results show that even the smallest representative farms can provide, either through home production or through generating income, the necessary means to meet recommended family dietary allowance, and still create a surplus to cover other household expenses or to increase cash assets. Net revenue and total output reach a maximum by increasing farm resource commitment to cash crops. The study recommends placing a greater reliance on the market as a source for foodstuffs.

The study concludes that accelerated small farm development will depend on government policies and programs in the Azua region. A precondition to achieve growth is the extent of government commitment and the capability to act in order to promote small farm development. Market oriented production should be promoted because of the physical, environmental and locational characteristics of the region. It is suggested that price policies and credits could be effective tools to guide resource allocation into desired activities.

CHAPTER I
INTRODUCTION

Research Problem and Objective

During the last two decades, great efforts have been made to increase yield and total output of food crops. Because of these efforts, developing countries have achieved the remarkable increase in grain yield of 32 percent per hectare and an increase of 78 percent in total grain production, which is similar to that observed in the developed countries (Arnon, 1981). However, there is still hunger in the less-developed countries (LDCs). Worldwide statistics report that all nations theoretically are producing almost all food necessary to satisfy minimum nutritional requirements. On the other hand, the annual world population growth rate is 1.47 and the tendency is to increase. Thus, in spite of an increase in total food production at the same rate of the developed countries, per capita output in LDCs only barely keeps pace with population growth.

At the regional level, food production in the Caribbean has been declining and a serious food deficit is emerging (UNICA, 1983). This fact, coupled with a growing inability to finance food import requirements, calls for a rationalization of the agricultural sector. If population continues to grow at the current rate, countries in the Caribbean and Middle America would have to increase annually their cereal production by 9.43 percent to achieve self-sufficiency by the year 1990. Declining production in the Caribbean has been accompanied by a reduction of agricultural land under cultivation. This, in turn, has contributed to growing unemployment, rural-urban migration and malnutrition. Nutritional studies show that 44 percent of the Caribbean's population does not consume minimum recommended protein and calorie requirements (Phillips, 1982).

The Dominican Republic faces this general problem (ONAPLAN, 1978, 1980, 1983; SEA, 1976, 1979, 1981a,b). There is a need to increase total per capita food output above the population growth rate. There is a need to improve income and income distribution. There is a need to link improved nutritional standards with domestic production and to generate surpluses for export. There is a real need to improve the quality of life of the Dominican people by using rationally the resources at their disposal.

The State Secretariat of Agriculture (SEA) in 1976 identified both immediate and long-term problems facing the Dominican Republic and published a strategy for agricultural development. The short-term strategy (5 years) proposed at that time was to increase daily per capita calorie intake from 1424 to 1906 and protein intake from 28.23 to 43.24 grams per person per day (SEA, 1976).

SEA (1979) published a short-term development plan which called for maximizing use of natural, human, financial and institutional resources available in the country. This plan aimed to achieve the following objectives: 1) to improve nutritional levels of the population, especially of the lowest income groups; 2) to increase production levels; 3) to improve income distribution among the income classes and 4) to reduce imports of agricultural products and to increase agricultural exports as a means of compensating for the increased cost of fossil fuel. This plan also called for rational land use in order to avoid soil degradation, management of irrigation water, transfer of technology, and increase in small farmer income.

In the 1980's, SEA (1981a) published an agenda for food production and consumption. Two alternative production strategies were presented. The first proposed a production growth rate similar to the one observed during the past few years; the second assumed an extraordinary effort to increase annual production by 16 percent for particular crops. The consumption target was established as a function of the desired calorie and protein intake for the 1970 population. Actual availability was estimated at

2143 calories and 49.0 grams of protein per day, while the average target was set at 2443 calories and 57.8 grams of protein per day. Simple solutions such as a repetition of past production will not be enough to meet the future target of food supply and consumption.

SEA's operative plan for 1982 (1981b) presents specific crop production and consumption goals for about 22 commodities complete with programs and projects to meet these production goals.

The National Planning Office (ONAPLAN) has published two nutritional studies (ONAPLAN, 1978; ONAPLAN, 1980). The latter document provided a framework for the formulation of current food production policies and a national nutrition plan. Some of the policies proposed to cope with the consumption-nutrition problems are a better use of productive resources, an increase in per capita income, redistribution of income, and an increase in food production.

Some measures have been taken to improve the income of low income groups. The minimum wage of agricultural workers has been increased from $2.50 to $3.50 for 8 hours of work (law 45 of May 25, 1979). Income taxes were modified in favor of low income groups (law 39, May 1979). Agrarian reform settlements are being established in newly irrigated and dry land areas as a means to increase production and to improve income distribution. Notwithstanding these measures to aid low income farmers and farm laborers, no direct or latent policy measures have been taken to guide a rational use of resources at the small farm level. This is a surprising fact since a large share of the food produced in the Dominican Republic comes from small and medium size farms (less than 160 tareas); they contribute about 80 percent of the total food supply (SEA, 1981a).

Since the farm is the decision-making unit of food production, it should be at this level that national and regional interest is focused. Research should be directed at the farmers' motivation for resource allocation and at the means by which optimal resource allocation can be achieved.

At the farm-household level, nutritional issues take on a broader perspective. Small farmers are both suppliers and consumers of food products. Therefore, attempts to improve their quality of life require more indepth study in order to analyze the determinants of small farmer behavior. The rural social system is more complicated than it may seem: a high output along with low market prices may leave farmers worse off. Also, the nutritional level cannot be predicted from income nor from food production if prices are excessively high, if the marketing system is inefficient, or if the rural population does not have the right information about the nutritional value of food. Therefore, a more comprehensive approach must be developed to address rural development problems, one that simultaneously copes with problems related to production, distribution, consumption and growth of the rural household-enterprise.

There are three major problems confronting a large share of Dominican small farmers: low output, low income and malnutrition (World Bank, 1980). Because these problems usually are related to low productivity, solutions often address only one part of the problem and neglect the other two aspects. That is why many official programs often have benefitted only a small percentage of farmers, those who are in a position to take advantage of new knowledge, new techniques and institutional incentives. Thus, instead of contributing to narrowing the gap between low and high income groups, government policy has tended to accentuate the production-income-nutrition gap.

Nutritionists have concluded that improvement of the average family's diet should be given high priority in a national development plan. The basic argument is that the quality of human life will be enhanced and that the productivity of the workers will be increased through appropriate diets. By linking this nutritional need with the objective of biological survival of most small farms, at least two sources of inefficiency in resource allocation can be identified: i) lack of knowledge about the comparative advantages among cash crops and between cash crops and food crops; and ii) lack of knowledge about nutritional requirements and the nutrient content of foods. As a result, total food costs could be reduced in some cases, or alternatively, the diet could be improved at the same total food cost and income could be improved by a better assemblage of crops.

The southwestern part of the Dominican Republic is a region highly dependent on agriculture as a prime economic activity. The Azua plain is one of the most promising food production regions and an extensive network of irrigation and drainage facilities has been built to assist in its agricultural development. However, proposals for the development of the Azua plain have failed to apply analytical methods to evaluate the possibilities for producing alternative food crops by varying the availability of farm inputs, such as water, labor and capital (Avidan, 1969; IAD, 1969, 1977; ONAPLAN, 1975, 1977).

This study aims to develop a scientific base for solving the problem of resource allocation at the small farm level in the Azua plain. First a set of representative farms is identified in the newly irrigated area along with the most efficient alternative land uses in crop production for these farms. Data are aggregated for the newly irrigated area and information is generated at the regional level to help decision-makers plan farmland use and resource allocation. The general objective of this study is to develop and test a behavioral resource allocation model of farm production at both the household and regional levels by analyzing the effects of soil type, technology level, crop mix and farm size. The study attempts to combine natural resource and socioeconomic data to determine optimal resource allocation for production and consumption both on small farm units that are representative of the Azua region and for the newly irrigated Azua region as a whole.

The specific objectives of this study are

I) to develop an analytical method that will help decision-makers (small farmers and government officials) to evaluate the consequences of any decision made with respect to agricultural land use and resource allocation in the Azua plain;

II) to design and apply a dynamic resource allocation model that can assist in determining the optimal allocation of agricultural land and resources to a set of representative farms in the Azua plain and to the newly irrigated Azua region as a whole, where socioeconomic conditions are changing very rapidly over time;

III) to estimate the direct and the opportunity costs in terms of output or income foregone of alternative agricultural land uses for representative farms within the region and for the region itself;

IV) to provide recommendations to the farmers and government officials regarding alternative future land uses that may meet more closely the objectives of increased farm output and increased income levels so as to fulfill the recommended dietary allowance proposed for the country;
V) to offer insight into the relationships between family food needs and farm production;
VI) to offer public policy-makers information about farmer behavior with regard to different farm sizes in order to help improve the agrarian reform settlements, loans to small farmers and price policy in terms of fostering economic development in the region.

Characterization of the Dominican Republic

The Dominican Republic and Haiti share the island of Hispaniola, the second largest (77,914 km^2) of the Greater Antilles. The Dominican Republic occupies the eastern two-thirds of the island, covering 48,442 km^2 and is situated in a subtropical windward coastal location (17° 36'-19°50'N latitude and 68° 14'-72°01'W longitude) (figure 1.1).

Its insularity and relatively small size permit a strong maritime influence to control the general climatic patterns (Hartshorn et al., 1981). The physiographic

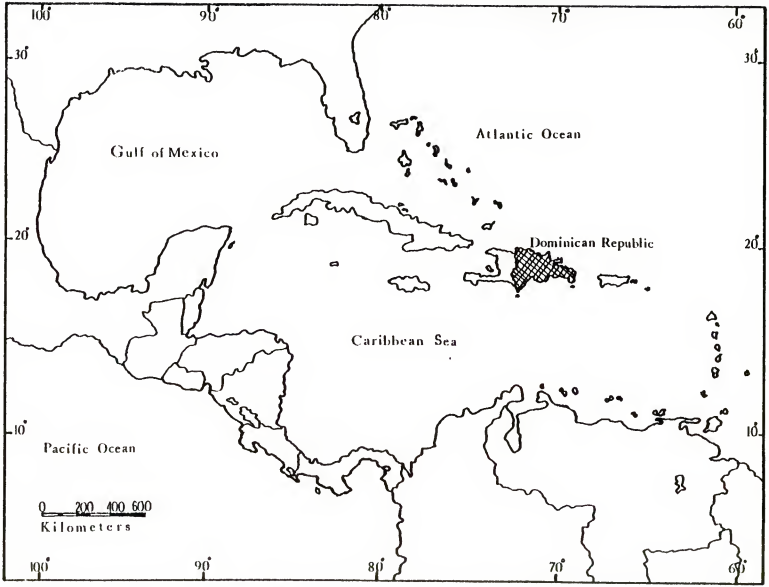

FIGURE I-1: LOCATION OF THE DOMINICAN REPUBLIC

complexity of the country adds considerable heterogenity and variability to local climatic regimes.

Four major parallel mountain ranges trend northwest-southeast. The Central Mountain Range extends from northwestern Haiti almost to Santo Domingo (the capital city). This range boasts the highest peak of the Antilles (Pico Duarte, 3,807 m). The central location and extent of the range make it the source of all the major rivers. The central highlands are characterized by poor, shallow soils dominated by the native pinus occidentalis. However, this same mountain range delimits the three major valleys of the country (the Cibao, San Juan and Enriquillo basin), which are the most important agricultural regions containing the best agricultural soils. Patches of coastal plains are to be found along the Caribbean and northern coast, the Caribbean coastal plain being the most extensive and important one. The Azua plain is situated on the Caribbean coast.

The Republic's insularity and heterogeneous topography determine local climatic regimes that vary markedly from arid to wet, lowland to montane. Although frost is common at high elevations and snow can be found occasionally on the highest peaks, temperatures vary regularly and predictably. Even polar air masses can push cool air over the Dominican Republic's north coast during the winter.

Atmospheric moisture and wind conditions can accentuate local temperature differences (Hartshorn et al., 1981).

The amount and distribution of rainfall play a very important role in determining natural vegetation and influencing agricultural crop production. Rainfall varies sharply in the country (from 350 mm in the Neyba valley to 2750 mm at Laguna Limon). In most of the Republic, the success of cyclical, non-irrigated crop production is dependent upon seasonal fluctuations in rainfall. The dry season usually occurs from December to March. However, the northern mountain range is wettest from November to January, due to a strengthening of the trade winds (Hartshorn et al., 1981). The rainy season is from May to November, the period of weak trade winds, and includes the possible occurrence of hurricanes, responsible for strong winds and heavy rains.

The Dominican Republic is an island nation of limited territory. In 1981, its population was 5,700,000 (estimated) and the average density was 115 inhabitants per km^2. However, if only the good agricultural land is taken into account, the density goes up to 267 inhabitants per km^2. This relatively high population density (in comparison with other Latin American countries) is of concern, as only 43 percent (20,836 km^2) of the total land area is classified as land of high or moderate agricultural

Table 1.1: Agricultural Land and its Potential, by Region in the Dominican Republic, 1977.

Number	Region	Total land km^2	Farmland km^2	Poor land inadequate for cropping km^2	Land of moderate or high agricultural potential, km^2
I	North	9065	6044	5855	3210
II	Northeast	5329	4796	3064	2265
III	Norhwest	4769	1952	960	3804
IV	Central	6983	5127	3963	3020
V	Southwest	7503	2031	3853	3650
VI	South	6885	1321	4488	2397
VII	East	7745	6176	5260	2485
Total	Total	48,279	27,452	27,443	20,836

Source: Hartshorn et al, 1981.

potential, whereas 57 percent (27,452 km^2) of all land in 1977 was used for farming activities (table 1.1).

Even though productivity is low, the agricultural sector has played, and must continue to play, the most important role in the economic development of the country. Fifty-eight percent of the total labor force is devoted to agricultural activities, but this sector only produces 17.0 percent of the Gross Domestic Product (GDP), whereas 9 percent of the labor force is engaged in manufacturing activities which produces 19 percent of the GDP.

The stagnation of agricultural output in the Dominican Republic during the last 6 years has been of concern to the government and the private sector (Angeles Suarez, 1983; Listin Diario, 1982; ONAPLAN, 1983). The stagnation of the output has been measured in terms of the growth rate of the GDP. GDP has increased at a rate of less than 4 percent per year, which is the minimum required to meet the domestic demand for food. The estimated population of the Dominican Republic grows at a rate of 3 percent per year and per capita income grows at 1 percent per year or more.

The rate of growth of cropping activities has been less than that of livestock activities. Both (combined) have grown less than the total economy (table 1.2).

Table 1.2: Growth Rates of GDP for Crops, Livestock and the Economy as a Whole, Dominican Republic, 1971-1980.

Year	Growth rate of GDP (priced at 1970)		
	Crops (%)	Livestock (%)	Global economy (%)
1971	6.6	6.0	8.4
1972	-1.2	5.3	12.3
1973	13.8	3.8	12.2
1974	0.1	-0.6	7.4
1975	-5.8	5.6	5.1
1976	9.1	4.1	6.2
1977	-0.2	7.2	5.0
1978	2.6	8.4	2.1
1979	-2.0	3.0	4.7
1980	3.0	7.5	5.8

Source: Banco Central de la Republica Dominicana, Departamento de Estudios Economicos, 1981.

The economic growth of the country has not improved the welfare of the masses (World Bank, 1980). Growth during the last decade was confined to a relatively small segment of the urban population, leaving the majority of urban dwellers and the rural population unaffected or even worse off than before. If urban unemployment is high (about 24 percent of the economically active population in Santo Domingo in 1977-1978), rural unemployment and disguised unemployment are even higher.

Farmers and rural people in general have profited least from development in the Dominican Republic during the last two decades (Quesada, 1981). The rural poor are poorer than the poor of the cities (table 1.3) The highest poverty level is found among farmers: the mortality rate is higher for all ages, in part due to lower sanitary conditions; illiteracy rates have been higher among farmers and the rural population than in the urban areas.

The agricultural sector is the largest employer. According to the 1971 census, 56 percent of all employment was provided by the agricultural sector. Even though the rate of rural-urban migration was high, around 56 percent of the active population was still to be found in the rural areas by 1979 (SEA, 1980).

Seventy nine percent of total farm employment took place on the farm while the remaining 21 percent was related to off-farm jobs. This implies that the average family farm is selling labor away from the farm while at the same time contracting labor from outside during some seasons. It is suggested also that an active labor market exists and that a large group of people who own no land make a living working as agricultural workers.

Recent research suggests that economic factors are the most important motive for migration out of the rural sector (Quesada, 1981; World Bank, 1980). Quesada shows that rural-urban migration is increasing at a high rate because the economic policy followed by the public sector has been discriminating against agricultural consumers and has favored urban consumers. This discrimination is being carried out through price and trade policies.

Unemployment is one of the country's most serious problems. The 1970 Census reports an open unemployment of 24 percent of the labor force, but this is an ambiguous concept in the Dominican ecomomy where disguised unemployment is very high. Also, the large number of non-productive jobs must be taken into account, especially in the public sector and in government-related institutions. Job creation has failed to keep pace with increases in the labor force, which has been growing at an estimated annual rate of 3 percent. Sluggish agricultural development (averaging 3 percent yearly during the 1970's), slow and ineffective implementation of the agrarian reform, and an incentive system that encourages extensive agricultural land use have contributed to the continuing rural exodus (World Bank Report, 1980). A better integration of development efforts for agricultural/rural and industrial/urban development is urgently needed in order to reduce internal migration and unemployment, which is accumulating at an alarming rate in the cities.

Since 1974, after the slowing down of the economy, urban employment has deteriorated very fast. The root of the problem lies in the rural areas where labor is under-utilized and where no alternatives exist for non-agricultural or agriculturally-related activities. Therefore, the problem of urban unemployment has to be tackled through changes in agricultural labor utilization, which presupposes more intensive land use.

The 1976/77 household survey reveals that 50 percent of the population had a per capita income below the poverty level (World Bank, 1980). In this study, a person lives in absolute poverty if the available income is insufficient to provide for an adequate diet and minimum non-food expenditures. The diet is considered adequate if it meets the minimum recommended intake of calories and protein based on local consumption patterns. The percentage of the population living below the poverty line was higher in the rural areas than in the urban areas (table 1.3).

Income distribution among households and individuals is very uneven. The income distribution in rural areas shows that over one-third of the population falls into the lowest category, with an income of under RD$20.0 per month, which is below the rural poverty level (RD$22.0). Almost

Table 1.3: Incidence and Intensity of Absolute Poverty, Dominican Republic, 1976-1977.(a)(*)

	Urban	Rural	Total(b)
Absolute poverty threshold, monthly	RD$ 37.60 (c)	RD$ 21.88	N.A.
Percentage of families with per capita income under poverty level	37.5% (41.9%)	36.4% (44.2%)	37.0% (43.1%)
Percentage of population with per capita income under poverty level	45.2% (49.4%)	42.9% (50.7%)	44.0% (50.1%)
Poor's share of total income	16.9% (19.3%)	19.3% (22.8%)	17.7% (20.9%)
Average family income of the poor (monthly)	RD$162.62 (152.80)	RD$106.00 (94.48)	RD$134.60 (122.67)
Average per capita income of the poor (monthly)	RD$ 24.37 (23.38)	RD$ 14.85 (13.62)	RD$ 19.49 (18.19)
Poverty gap (d) as percentage of average income of the poor	47.5% (53.8%)	43.5% (56.3%)	54.9% (54.8%)
Sen-index of poverty	21.5 (26.6)	18.7 (28.5)	20.2 (27.5)
Average per capita income of respective population	RD$ 65.16 (59.88)	RD$ 33.13 (30.92)	RD$ 48.36 (44.34)
Average family size of poor households	6.674 (6.536)	7.138 (6.939)	6.904 (6.731)
Family size of poor as percent of family size of total population	120.5% (118.1%)	117.9% (114.6%)	119.1% (115.3%)
Estimated size of poor population	1,068,600 (1,167,900)	1,120,900 (1,324,800)	2,189,500 (2,492,700)

(*): explanation on next page

Table 1.3 continued

(a) Figures in parentheses are computed on the basis of reported income, whereas all other figures were derived from "adjusted income." Adjusted income equals expenditure if reported income is less than expenditure, and equals reported income otherwise.

(b) For national estimates, an urban sub-sample was weighted by a factor of 1.39, so that urban population = 47.5% of total population.

(c) These thresholds actually were not applied in the calculation of the incidence of poverty. Individual thresholds taking the number of consumption units of individual families into account were used instead.

(d) Difference between average poverty level and average per capita income.

Source: The World Bank, Report no. 2803-DO, 1980, p. 105

two-thirds of the rural population has no more than RD$30.0 per month. The situation is different, however, in the urban areas. High income households are found more likely in the urban areas (8 percent versus 3 percent) and urban income is significantly concentrated within the urban middle class (about 48 percent) and is relatively evenly distributed (World Bank, 1980).

Gini-coefficients were estimated as a measure of concentration of income based on ungrouped, individual household data. Coefficients were significantly higher for urban than for rural areas (0.4711 versus 0.4341) (World Bank, 1980). These coefficients are normal in comparison with other Latin American countries (appendix A). In general, household survey data suggest that the population in Santo Domingo (the capital city) has become poorer in terms of real per capita personal income during the last decade. This development was accompanied by a slight change in income distribution in favor of inter-personal distribution (figure 1.2).

There has been a persistent food deficit over the last two decades. During this period, per capita agricultural value added has declined. Per capita production of food crops has shown only small increases that do not meet the rate of population growth. This has contributed in part to widening the gap between aggregate demand and GDP. As a consequence, food imports have been increasing over time to fill the gap between aggregate food production and

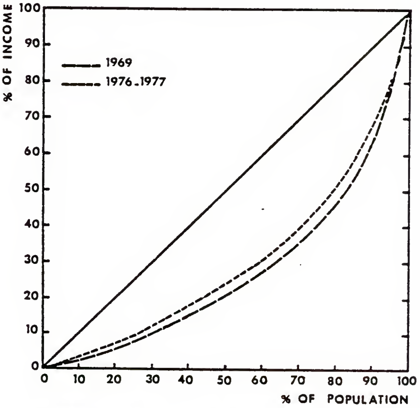

FIGURE 1·2: LORENTZ CURVES OF INCOME CONCENTRATION (REPORTED INCOME), SANTO DOMINGO, DOMINICAN REPUBLIC, 1969, 1976-1977 aggregate food demand. The country presently is importing agricultural commodities which it used to export or for which it was nearly self-sufficient (rice, beans, corn, edible oil).

Since 1963, the nation has shown a negative balance of payments (appendices B and C). The increase of foodstuff imports from 1973 to 1977 was estimated at RD$40.43 million (Chanlatte, 1983). In 1981, total foodstuff imports amounted to $124.3 million, of which rice, corn and edible oil accounted for 79 percent (RD$98 million). Both food availability and food consumption have increased. The increase in per capita consumption, though, has not met as of yet the minimum level of recommended consumption based on the 1977 pattern.

The consumer price index for the years 1978, 1979, and 1980 increased respectively 7.1, 9.2 and 16.7 percent (Banco Central, 1981). After the dramatic 1979-1980 rise, prices kept increasing but at a more moderate rate.

Though the Dominican Republic per capita GNP (RD$840 in 1977) compares favorably with other Latin American countries, the incidences of absolute poverty and nutritional deficiency are unexpectedly high. The recommended daily diet for the country, according to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), has been estimated at 2300 calories and 47.5 grams of protein (ONAPLAN, 1978). By

1981, however, per capita availability of calories and grams of protein were estimated at 1460 and 38.6, respectively (SEA, 1981c). This implies the existence of a daily deficit averaging 840 calories and 8-9 grams of protein. Given the disparities in income distribution, it is suggested that diet deficiency among low income groups is quite high. The severity of this rural poverty problem underscores the need for governmental policy and action.

The Dominican Republic is facing immediate and long-term social and economic problems. Economic growth has been relatively slow since 1974, when major expansionary impulses declined in the mining and industrial sectors. Average annual GDP growth declined to 5 percent during 1973-1978 as compared to the record height of 11 percent during 1968-1973. Because of remarkably high sugar prices, the country's main export product, the increasing cost of fossil fuel was disguised for some time and no adjustment was made (World Bank, 1980). The effect of this policy was not felt until 1976, when sugar prices declined sharply and the nation experienced a heavy current account deficit in its balance of payments. These immediate problems have forced attention away from the long-term needs for adequate socioeconomic development.

The country shares a common experience with other LDCs: the structure and the performance of the economy is related closely to the agricultural sector. The growth of the economy has been related to international trade, exporting agricultural comodities and raw materials (sugar, coffee, cocoa, tobacco and minerals) and importing capital, durable consumer goods and more recently, foodstuffs.

Study Region

The Azua plain is a piedmont alluvial fan situated on the south coast of the Dominican Republic (figure 1.3). Alluvial soils are derived from the Yaque del Sur river which heads in the Central Mountain Range to the north. The Azua region, 70 kms by 32 kms in extent, is flanked by the Martin Garcia Hills to the west and the El Numero Hills to the east. The town of Azua is located at 76 m.a.s.l. Azua is connected by surfaced highways with Santo Domingo (150 kms to the east), San Juan de la Maguana (85 kms to the west) and Barahona (80 kms to the south). Secondary farm-to-market roads traverse the region. One locally important secondary road connects the port facility at Puerto Viejo with the Santo Domingo-Azua highway.

Both maritime and airport facilities exist in the region. Puerto Viejo was refurbished in 1956 at the cost of RD$5 million and can accommodate vessels with a 27-foot draft, but these facilities, along with the small airstrip, are hardly ever used.

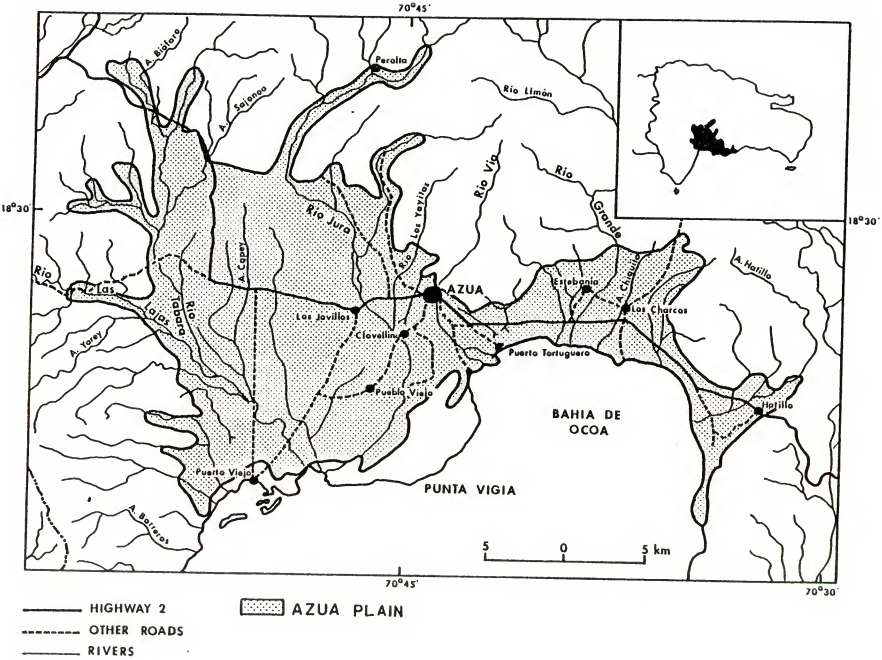

FIGURE 13: LOCATION OF THE AZUA PLAIN, DOMINICAN REPUBLIC

The 1984 population of the municipality of Azua, basically the area encompassed by the coastal plain, was estimated at 68,662 inhabitants. Approximately 34,000 lived in the urban area and 34,650 lived in the fifteen sections or rural communities. The average family consisted of six individuals. The level of education, as well as the level of farm productivity, was low (ONE, 1983).

About 47,700 ha (758,430 tareas) are suitable for intensive agricultural use. Soils are friable and slopes are less than 8 percent which makes the region fit for mechanization. Three main rivers, Via, Jura and Tabara, flow across the region. The volume of runoff has been estimated at 87.5 million m^3 (IAD, 1977).

Common crops in the region are plantain, tomato, green pepper, corn, sorghum and manioc. Until recently, availability of water was the main factor limiting any increase in farm production and agricultural productivity. A new network of drainage and irrigation canals will make approximately 47,000 additional hectares (758,430 tareas) available for food production. Figure 1.4 presents the annual cropping calendar for the major food crops of the region.

The Soils

The soils of the Azua plain, an eastern prolongation of the valley of lake Enriquillo, belong to two

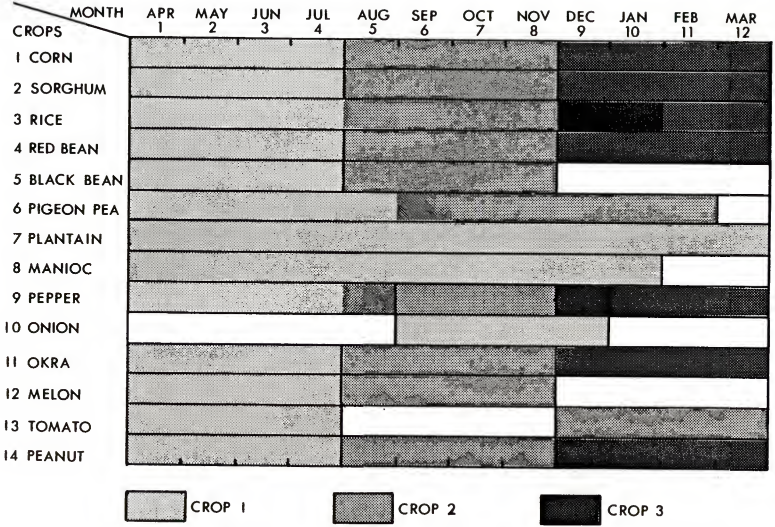

FIGURE 1·4: ANNUAL CROPPING CALENDAR FOR VARIOUS FOOD CROPS, AZUA, DOMINICAN REPUBLIC, 1984 physiographic groups, elevated terrace and old alluvial deposits and piedmont plains and alluvial fans. Various soil studies have been made using three different classification schemes(IAD, 1969; OAS, 1967; SEA, 1981c).

The most general classification was developed in a study by the Organization of American States (OAS, 1967). This classification was based on soil associations and four categories, I through IV, were distinguished as suitable for farming.

The second classification, corresponding to the one used in the "El Sisal" project, differentiates soils on the basis of irrigability (IAD, 1969). Sub-categories have been selected according to soil depth and soil composition.

A third classification was used to map the area irrigated by the Yaque del Sur canal and contains two categories, one based on potential land use and the second on irrigation purposes (SEA, 1981c). It contains six classes, indicating the nature and limitations of each soil type. The first three classes consist of arable land that can be irrigated and on which cropping is not restricted.

The present study uses the four land categories of the OAS soils map. Since these four categories were too detailed, they were regrouped as follows: group A consisting of categories I and II, covering the better land, and group B consisting of categories III and IV.

At the regional level the SEA soil classification was used to distinguish potential land use in the newly irrigated region. A distinction was made between farmland and non-farmland (appendix D).

Climate and Water Availability

Surface water constitutes the main source of water on the Azua plain. However, even the three principal rivers, Tabara, Jura and Via, remain partially dry for a greater part of the year. This is due to the soil conditions, infiltration and to the hot, dry climate of the Azua plain.

As a result of the porosity of the surface soil, nearly 27 percent of surface water is percolated into the water table, the percentage increasing as one travels south. Groundwater thus collected constitutes the second major water source of the region.

Another factor contributing to reduction of water volume in the rivers is the high evapotranspiration caused by the semi-arid climate. Annual temperature ranges between 25°C and 30°C and annual rainfall is around 700 mm. Precipitation is concentrated in the months of May, September and October, and is infrequent, intense and of short duration.

Irrigation projects have been started to ensure water availability throughout the year. Recently, the dams of Sabaneta and Sabana Yegua have been put into operation and are part of an intricate network of irrigation canals (totalling some 350 kms) deriving their water from the rivers Yaque del Sur and Tabara (appendix E). It has been estimated that an extra 25,000 ha (397,500 tareas) will come under irrigation. This could increase the number of families working the irrigated land by 400 percent as smaller plots of land are required per family when they are under irrigation.

Plan of Presentation

The first chapter of this study introduces the research topic and familiarizes the reader with the country, its problems and development perspectives. The study region is described in terms of the natural resource base and ecological limitations.

Chapter II reviews previous research in the field of agricultural development as related to man-land relationships and the resource allocation problem. This review includes a discussion of the production activities cast within the context of the problems of risk and uncertainty and consumption and nutrition theory. Then, the problem of aggregation in production is discussed.

Chapter III presents the theory of mathematical programming applied to the problem of resource allocation.

Chapter IV describes the methodology used, including the sample design,.data collection and analytical modelling.

Results are presented in chapter V. Primal and dual solutions under multiple objectives are presented.

Chapter VI offers a summary and conclusions. The limitations of this study are discussed and suggestions are given for future research.

CHAPTER II
THEORIES OF FAMILY FARM OPERATION

Development of theories about family farms in general, and relationships between small farmers and the land in particular, until recently have not been of major concern to researchers. Although a large part of world agriculture is comprised of semi-commercial family farms using a multi-cropping system, the study of family farmers' behavior as decision-makers in utilizing land resources, input allocation, technology adaptation-diffusion, and goal setting has been pushed to the background in favor of strictly production oriented studies.

A new consciousness has emerged in recent years regarding the political and economic significance of small farmers as they struggle for a better life. A number of empirical studies have been conducted on family farms and these studies have focused on finding ways of introducing new technology to farming or formulating effective rural development strategies (Andrews and Moore, 1976; Green, 1974; De Janvry, 1975; De Janvry and Deere, 1978; Langham, 1968).

Geographers and anthropologists have produced numerous empirical studies on farm-households but they have not generalized their findings. Economists have made more generalizations about peasant behavior. However, no peasant theory can be formulated that does not take into account the particular geographical, social and historical aspects and the purpose of the analysis.

De Janvry and Deere (1978) presented a general theoretical framework for the empirical analysis of peasants at five different levels of abstraction. This constitutes a useful typology that can be applied in different environments to build theories aimed at explaining site specific cases. The levels proposed are organization of peasant households, economic logic of peasant households, mechanism of surplus extraction (from the peasant households), insertion of peasants within a particular mode of production and dynamics of transformation of the peasantry as capitalistic development takes place. The advantage of these categories is that they link social processes over time, so that changes in a large number of peasant societies can be studied chronologically.

Several important theories have emerged in relation to peasant land association. These theories have had an impact on development policies. The remaining part of this chapter will be devoted to the discussion of such theories aimed at the clarification of the main postulates involved in family farm operation. These postulates will be used in chapter IV to build a representative model of the farm-household in the Azua plain.

Traditional Society and Family Farms.

The traditional society is pictured as a way of life based on long established folkways which suggests that traditional agrarian society, in general, and traditional agriculture, in particular, are not economic organizations (Brewster, 1967; De Zouza, 1974). Rather, they are essentially cultural-institutional arrangements of land ownership, cultural process, nature of production (home consumption or market), and technology level. Another way of approaching traditional society and traditional agriculture is by attributing particular cultural values to them. These values are related to work, inventiveness, thrift, and hope for a higher standard of living. These factors frequently are used to explain why so often there is little progress in traditional societies.

For policy purposes, however, the relevant questions are how to transform traditional rural societies, so as to overcome widespread poverty, conformism and illiteracy among small farmers; how to motivate the small farmers to improve their agriculture by incorporating better farming techniques; how to carry out reorganization, transformation and modernization so as to create an economic surplus; how to integrate these rural societies into the economy of the country; and how to make viable transfers of economic surplus from agricultural to non-agricultural activities.

Agricultural surplus has been an essential element of economic growth and development. Nicholl (1963) defined "agricultural surplus" as the physical amount by which, in any given country, total food production exceeds the total food consumption of the agricultural population. Accordingly, developing countries have not fulfilled the fundamental preconditions for economic development until they succeed in achieving and sustaining a reliable food surplus. The historical implication is clear: an agricultural revolution with a marked rise in worker productivity has been a precondition to industrial development in any part of the world.

Schultz (1964) has argued that a country totally dependent on traditional agriculture is inevitably poor and that most of its income is devoted to food. In countries with a modern agricultural system, however, people are free to work in other sectors of the economy. This enables the society to enjoy the benefits of a productive agricultural sector. There are comparatively few inefficiencies in the allocation of production factors in traditional agriculture. Therefore, no appreciable increase in agricultural production will occur by reallocating the production factors at the disposal of farmers bound by traditional agriculture. This theory implies the existence of a "low level" equilibrium trap which does not allow change in traditional agriculture without significant external inputs. This point of view reduces the problem of traditional agriculture to an investment problem. Namely, transformation of the sector only can be achieved through investment. In addition, it is argued that the problem is not one of supply of capital but rather of the form of profitable investment.

Schultz's purpose is to show that a logical economic basis exists to explain why traditional agriculture employing only the production factors at its disposal is incapable of growth except at a high cost. Furthermore, Schultz tries to show why the rate of return on investment in modern agricultural inputs can be high by past growth standards. Accordingly, the main questions to answer when dealing with traditional agriculture are: can low income countries increase agricultural production substantially by a more efficient allocation of the production factors presently at their disposal; which agricultural factors are responsible for rapid and sustained growth; and under what conditions is it profitable to invest in agriculture.

All of these questions are economic in nature. What Schultz fails to address are the historical, cultural and anthropological aspects of the problem. It should be noted that today in most traditional societies, a modern agricultural sector coexists with a traditional sector in such a way that each one acts independently of the other, plays different roles and responds to different groups in the society.

The writers discussed above have analyzed agricultural poverty in the context of traditional agriculture, defined as a state of economic equilibrium in agriculture reached over a long period of time. In this context, the origin of agricultural poverty is disassociated from the dynamics of development of other agricultural sectors, from other economic activities, and from the world economic system. In contrast to these writers, De Janvry (1975) notes that underdevelopment cannot be treated apart from development if backward areas or countries are related to the advanced areas of other countries by the market. A theory of underdevelopment and rural poverty must incorporate a theory of economic space, which explains how the contradictions of development in certain areas can transform traditional societies into underdeveloped ones.

Peasant Farm as a Subsistence Farm

Most recent literature reveals that subsistence farming covers some 40 percent of the cultivated land in the world and supports 50 to 60 percent of mankind (Arnon, 1981; Manshard, 1969; Steven, 1977; Wharton, 1969). However, theories and facts about subsistence agriculture are not enough to understand the functioning and the dynamics of this type of rural organization, nor to understand programs and policies for development of subsistence agriculture. Perhaps the reason for this is the limited participation of subsistence farmers in the market and the tendency among social scientists to analyze subsistence agriculture in terms of market participation. In recent years, however, some attention has been paid to peasant behavior and subsistence farming in developing countries, attempting to conceptualize its functioning and the way in which it can be used as an effective vehicle to promote social progress and national stability (De Janvry, 1981; De Janvry and Deere, 1978; Stevens, 1977; UNICA, 1976, 1983)

A problem to face when analyzing subsistence agriculture is to determine the extent of subsistence of the agricultural entity in question as well as the level of analysis. Confusion about the term "subsistence" has risen because it has been used both to describe the minimum of food and shelter necessary to support a life as well as the sources or means of obtaining that minimum (Wharton, 1969).

A pure subsistence farm sells no production to and purchases no inputs from external sources. It is a self contained unit and is characterized by a total absence of commercialization and monetarization. However, "pure" subsistence farms rarely are found in reality. What does exist is a continuum, a spectrum with pure subsistence farming at one extreme and pure commercial farming at the other extreme.

Nakajima (1969) presents a two dimensional-diagram by which all farms in the world can be classified (figure 2.1). Two criteria were used, the degree of subsistence of production (the proportion of production consumed or sold) and the degree of being a family farm (the proportion of family labor or hired labor in total input on the farm). The pure subsistence farms are located in the lower left corner, the commercial non-family farms in the upper right corner. Farms in the upper left corner are commercial family farms and farms in the lower right are subsistence

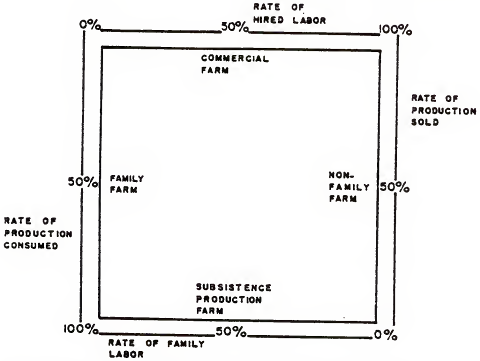

FIGURE 2·1: DEGREE OF SUBSISTENCE FARMING ACCORDING TO ITS MARKET ORIENTATION

SOURCE: NAKAJIMA, 1969

production non-family farms. The other locations represent a wide variety of farms all with different degrees of subsistence.

An important characteristic of subsistence farms is the close relationship between farm and home, production and consumption. It is a unified process. A representative subsistence farm is one which is integrated with the outside world. The degree of integration can be measured by the rate of the farm marketed product ratio, hired labor ratio, level of technology, standard of living, freedom in decision-making and other socio-cultural criteria.

The representative subsistence farmer is one who does not preclude market exchange, on the contrary, he has the dual goal of supplying foodstuffs for the family in the first place and for the market in the second place. This is so because the primary obligation is to the family. In this sense, subsistence agriculture is an objective and in order to fullfill this objective a mixture of both commercial and home consumption crops usually are grown. The growing of commercial crops does not imply a surplus of food crops. On the contrary, sometimes commercial crops are grown to acquire foodstuffs or industrially processed foodstuffs the farmer does not or cannot grow. This is true particularly in the Dominican Republic where subsistence farmers in arid regions grow sugar cane to generate cash income to enable them to buy hulled rice, edible oil, spaghetti, dried fish, sardines and other products. Subsistence farmers in humid regions grow rice exclusively, of which a large percentage goes to the market to generate the cash income needed to buy other foodstuffs such as beans, meat, edible oil and tomato paste.

An important aspect of traditional agriculture and subsistence farming is how labor, land and capital are allocated. Analysis of labor allocation in traditional agriculture depicts the farm-family decision-maker as allocating the available labor between non-economic activities and production of goods and services (Nakajima, 1969). In this context, the subjective allocation of labor between leisure and work is the primary determinant at the level of output. The effect on output of government policies covering prices, technological change, supply of consumer goods, land distribution and the like depend in large part on how these policies affect the use of labor. This is in contrast to modern agriculture which depends to a large extent on the purchase of inputs to determine output level. In this situation, agricultural output is affected very differently by public policy. Theoretically, farmers' decisions about labor allocation can be depicted by means of a utility surface in which the transformation of leisure into material goods and services describes the marginal rate of substitution of labor (Nakajima, 1969).

Nakajima (1969) argued that the influence of policy on farm labor allocation can be divided into an income effect and a substitution effect. Thus, ceteris paribus, a fixed tax policy, such as land tax, has only an income effect, which will reduce income and increase marginal utility of material goods and services. This, in turn, will cause farmers to put more labor into the production process. The labor-oriented theory of the role of agriculture in economic development is related to this aspect. Most of these theories are concerned with the transfer of labor from agriculture to non-agricultural activities (Lewis, 1954; Ranis and Fei, 1961). A well tailored tax policy may extract a surplus which could be produced by using idle labor more intensively from the agricultural sector and transfer it to a growing urban population through some kind of subsidy.

It is said also, that traditional agriculture does not respond to price incentives. Studies in this area show not only that they do respond to price incentives, but that they respond also to other incentives such as malaria control, which enable them to increase the area planted. Behrman (1968) in a study in Thailand found that farmers in traditional agriculture are significantly responsive to price with respect to total supply, and especially in the marketed supply of crops such as rice and cassava. Other policy incentives, such as the improvement of transportation, roads and increased availability of attractive consumer goods, may serve to increase the marginal utility of material goods and services and at the same time may reduce the marginal utility of leisure encouraging small farmers to increase labor input for market oriented production.

The man-land relationship in a traditional agricultural system is a complex matter mainly because people's cultural attitudes influence changing values over space and time. Society determines the system of land rights used. In a traditional society, for example, individual "property rights" to land are controlled by the community which allows the individual certain benefits from the use of land and the right to transfer the use of land to some other person. This limitation of land rights may be compared with limitations in modern western societies, where land use restrictions are based on some long-term community interest.

According to Firth (1969), land ownership in a peasant society is a parcel of rights covering pieces of land, but the items in the parcels are arranged and constituted differently. One of these items is the set of rights of kin groups of which the individual is a member. For instance, each individual manages his land in accordance with the need of his kin group. In case of death, inheritance of the land obliges the next owner to follow the same management patterns as used before in order to keep fulfilling group needs.

Property rights have been and still are regarded as a major force in peasant communities. Most of the literature reviewed agrees that in a peasant economy, institutional patterns of land control (collective, communal, individual and so forth) are fundamental factors affecting land use and the economic process. However, Georgescus-Roegen (1969) argues that this doctrine is spurious as it ignores the fundamental fact that institutions within peasant communities have never sought to control the land but the "flow" factor or income that is generated by the land.

The previous sections discussed the important role that labor and land play in traditional agriculture with limited capital. However, as development and modernization take place, capital becomes more important. The extent to which agriculture provides its own capital goods becomes a fundamental issue. The stock of capital and the share of income invested are low in traditional agriculture. This is due in part to low income and social values that encourage present consumption. Furthermore, it should be recognized that savings and investment in traditional agricultural economies are low because the rate of return is low. The return from capital is low because most capital goods are formed directly from labor, which in turn has a low rate of return. This is associated also with backward technology, which is responsible for reducing the productivity of capital and labor.

Most theories of agricultural modernization and growth have been limited to cataloging relevant inputs, recognition of complementarities of inputs, and subsequent diagnosis in order to determine which inputs are most likely to be the limiting factors under various circumstances (Boserup, 1965; Farrington, 1977; Schultz, 1964). In many instances, one forgets that modernization is a spatial diffusion process which assumes geographical patterns of varying intensity and rate.

The simplest theory of agricultural modernization is represented usually by a production function depicting agricultural output as a function of various inputs. Those inputs are divided into three categories: inputs used in traditional agriculture; inputs used in modern agriculture; and inputs used in modern and traditional agriculture alike. The new inputs of modern agriculture are institutional products that come from research and educational facilities and diffuse through a geographical space.

Mellor (1962) has suggested that the low productivity of traditional inputs is due to the lack of inputs of technological change that are needed to complement them. New inputs would have a high marginal productivity, causing on introduction an increase in productivity of the existing resources in traditional agriculture. This has been the experience of India and Japan (Ruttan, 1982).

Modernization makes possible the substitution of inputs with a relatively elastic supply curve. For instance, inorganic fertilizer is a substitute for organic fertilizer. Pesticides and herbicides may substitute for labor as well as tools and machinery. Therefore, the supply schedule, which initially is relatively inelastic for modern inputs, may become more elastic for commercial inputs as diffusion of new technology and agricultural development takes place.

Farm-Household and its Environment

Most attempts to analyze the economic behavior of farm-households have been based on the Chayanovian theory of utility and demography differentiation or on the neoclassical approach derived from the theory of the capitalistic firms (De Janvry and Deere, 1978). The rural economic system is complicated in that a large part of world agriculture is comprised of semi-commercial family farms or farm-households. These agricultural households combine two fundamental units of micro-economic analysis: the household and the family. Traditional neoclassical economic analysis has treated these two units separately and has failed to consider their interdependency within developing agricultural systems. Theories and models of farm-households in developing countries should be oriented towards the integration of production and consumption activities within the context of a single theory of behavior (Ahn et al, 1981).

Neoclassical economists regard the farm-household as a business enterprise incorporating two functional units: the farm as a producer and the household as a consumer. Most attention has been focused on the farm as a unit of production or the farmer as a profit maximizing entity. Little concern has been given to the fact that profit maximization may not be the family's objective.

The generalized concept of this type of agriculture implies a long established routine with respect to all production activities. It is a system of farming based wholly upon the kind of production factors that have been used by farmers for generations (Schultz, 1964). In other words, family farms are governed by a state of low level economic equilibrium reached over a long period of time. In this context, farm-households and their environment are disassociated from the dynamics of development in other sectors of the economy and from the introduction of new technology.

For Chayanov (1966), the essential characteristic of capitalistic enterprises is that they operate with hired workers in order to earn a profit, while the peasant family farm normally operates without hired labor. Thus, family-farms are pure in the sense that they depend only on work of their own family members. However, Chayanov's definition of family-farms is limited compared to how the concept is defined today. An idealized modal Russian farm, in the Chayanovian view of the first quarter of the twentieth century, had no hired labor at all. Chayanov challenged the validity of standard economic theory in analyzing the economic behavior of peasant farms and argued that neoclassical economics has been developed to explain the behavior of capitalistic enterpreneurs using hired labor as a major input in the production process. Therefore, in order to determine profits, quantitative interrelationships of wages, interest on capital and rent of land, have to be measured. The value of total output should be set down in such a way that differences between total value of the product and total expenses (wages, rent, and interest that might be earned at the going rate on the total capital) could be calculated. Wages, interest, rent and profits are interdependent and determined simultaneously. However, when one of these four factors does not exist, the remaining ones cannot be calculated. Chayanov stressed that the family-household must be considered an inseparable unit for the purpose of economic analysis and he treated their annual product minus their outlays as a single return to family activity. this return being indivisible and undifferentiable. This led to a rejection of the classical economists argument that wages for each member of the family could be imputed on the basis of prevailing local wages, and that each unit of additional labor as well as any other input used must further profit. There is no room for hiring idle resources. However, farm-family operation always pays wages, no matter whether labor is expended on the farm or not, because family members have to eat even if they do not work on the farm. In this case, the contribution of labor to production is zero, but the laborer receives a positive wage, which could be a subsistence wage, but it is still higher than his marginal contribution to output.

Chayanov's contribution to analyzing the farm-family is what he called the concept of labor-consumer balance between satisfaction of family needs and unpleasant work of the family labor. The return from labor to the family for a one year period is given by what is left at the end of the year after deducting from the gross product all the expenses made in that period and the expenses needed to restore the farm to the same level of production at the beginning of the period. According to Chayanov, the main difference between the farm-household's or peasant family's behavior and capitalist farmer's behavior is in the prices paid for inputs and prices of products sold. For instance, for conditions where capitalist farms would go bankrupt, family farmers will work harder, sell at lower prices, reduce their standard of living and continue farming.

In summary, there is a great deal of disagreement in how to analyze economic behavior of farm-households. Perhaps the disagreement has risen because most theories have tried to generalize a phenomenon which has particular characteristics in each society, as for instance in the case of the Azua plain. There, the farm-households are not entirely peasant nor are they entirely capitalist, but they have a heavy orientation towards the market although some family food is produced on the farm.

The nature of the existing agricultural base strongly conditions the development process of agriculture as well as the strategies used to achieve development. This may explain why the Soviet Union used a different strategy than China, Japan or Mexico. A theory of agricultural development, therefore, should give attention both to ways of increasing agricultural production within its traditional structure and to the means and consequences of its modernization.

Farming in most of the low income areas of the world is dominated by the family. Small household units make all management decisions and control most farm labor, supply and capital. Business considerations and household are contained within the same unit. The main issue is the extent to which small farmers make rational economic decisions. This writer assumes that they do. Therefore, small farmers' actions may be changed in a predictable manner by managing the economic environment.

Agricultural transformation and modernization is more than a process of increasing the productivity of the traditional resources already employed. It is the diffusion of new methods of combining resources, of new inputs and new techniques for handling crops, including storage, processing and distribution of the agricultural output. It can be concluded that a precondition for development of agricultural production is the existence of an environment in which the benefits of an increase in output go to the farmer decision-maker as an incentive.

In farm-household agriculture, the objective of the economic unit may be the stability of the family through production of a large range of crops and/or maximization of total output for future consumption or sale in the market. Having taken into account all these aspects, there is not a single definition of the farm-household and this study will not attempt to give it. However, any definition of farm-households or family farms in agricultural development should be broad enough to include all ranges of possibilities of this type of production-consumption unit.

CHAPTER III

MATHEMATICAL PROGRAMMING APPROACH TO AGRICULTURAL LAND USE AND RESOURCE ALLOCATION PROBLEMS IN AGRICULTURE

Small-farmers in less-developed countries face daily decisions regarding what to produce, how to produce and how to distribute production. Several operation research techniques such as mathematical programming are available and can help farmers and agricultural planners answer these questions. These techniques assist in problem-solving by applying scientific methods.

The process begins by carefully observing and formulating the problem, followed by the construction of a scientific mathematical model. This model attempts to abstract the essence of the real world with sufficiently precise detail so that conclusions obtained from manipulating the model are valid in resolving the real problem. A successful model must provide insights to and formulate conclusions for decision-makers.

Mathematical programming is one such operations research technique. It is concerned with how to allocate limited resources among various organizational activities. The full impact of mathematical programming, in general, and of linear programming, in particular, came into its own in the 1950's when the duality of constrained optimization and economic evaluation was established by Gale, Kuhn and Tucker (1951). Optimization became an important planning tool with the development of Dantzig's simplex method for linear programming. Mathematical programming is a general term covering linear programming, non-linear programming and game theory. It differs from classical optimization in that it is concerned with problems in which optimization is subject to inequality constraints.

Theory of Linear Programming.

Linear programming (LP) typically deals with problems of allocating limited resources among competing activities so as to maximize or minimize some objective function. Such a problem arises whenever one must select the level of certain activities that compete for scarce resources. There are various situations in which this applies. This study, for example, is concerned with the application of the LP technique to farmland use and resource allocation problems in agricultural planning.

Linear programming uses a mathematical model to describe the problem in question. Programming is used as a synonym for planning. Thus, linear programming involves the planning of activities to obtain not just a good, but the optimal result, when a number of resources such as labor, material inputs, financial resources, machinery, and land are available. However, certain restrictions exist on all or some of the total amount of each of the available resources.

The essential characteristic of linear programming is that all relationships between variables are assumed to be linear, continuous, additive and deterministic. Linear programming presents great flexibility as a tool for agricultural planning. Models can be formulated to accommodate different kinds of variations of the individual farms and the socio-economic environment of the farm. As a matter of fact, one may consider all types of available resources, the rate at which these are used, and the contribution of each to fulfilling the objective.

This model could take many forms depending on the problem at hand but, in general, mathematical programming can be expressed as

$$\text{(3.1)} \quad \text{maximize (or minimize)} \; f(x)$$
$$\text{subject to } gi(x) \leq bi \qquad i=1,2,3,\ldots,m$$
$$x \geq 0$$

where f(x) and gi(x) are real value functions of x and the vector bi is known. Special cases of this problem are linear programming problems where f(x) and gi(x) are linear functions of x, of which the matrix notation is

$$
(3.2) \qquad \begin{array}{rl} \text{maximize} & C'X \\ \text{subject to} & AX \leq b \\ & x \geq 0 \end{array}
$$

where

$$
C=\underset{nx1}{\begin{bmatrix} c1 \\ c2 \\ \cdot \\ \cdot \\ cn \end{bmatrix}}, \quad X=\underset{nx1}{\begin{bmatrix} x1 \\ x2 \\ \cdot \\ \cdot \\ xn \end{bmatrix}}, \quad A=\underset{mxn}{\begin{bmatrix} a11 & a12 & \cdots & a1n \\ a21 & a22 & \cdots & a2n \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ am1 & am2 & \cdots & amn \end{bmatrix}}, \quad b=\underset{mx1}{\begin{bmatrix} b1 \\ b2 \\ \cdot \\ \cdot \\ bm \end{bmatrix}}
$$

This problem can be described as follows: given a set of m linear inequalities or equations and n variables, one is able to find the non-negative value of these variables which will satisfy the constraints and maximize or minimize some linear functions of the variables (Hadley 1971). Three of these are column vectors, C and X being of the dimension nx1, but b being mx1. Vector C represents the coefficients of the objective function. In other words, these coefficients represent the contribution of each associated activity to the objective. Vector X represents the level of activities and vector b the maximum or minimum availability of resources. Matrix A is an mxn array which represents the input-output or technical coefficients. This refers to the amount of resources required to generate one unit of output. Given these definitions, the objective function in (3.1) can be expressed by the equation $\Pi = C'X$, which represents a scalar. This structure may be seen as too rigid. However, once the model has been designed to meet this structure, some flexibility is allowed through the use of some artifices, such as parametric programming, flexibility constraints, and so forth.

Since the objective function is continuous and the opportunity set is assumed to be closed, a solution to the linear programming problem exists if the opportunity set is non-empty and bounded (this is based on the Weierstrass theorem, which states that a continuous function defined over a non-empty compact set obtains a maximum and a minimum at least once within the set (Intriligator, 1971). Therefore, there are two circumstances in which there might not exist a solution to a linear programming problem. The first is if the constraints are inconsistent so the opportunity set is empty, and the second is if the opportunity set is unbounded and the objective function increases without limitations in this set (Intriligator, 1971). In general, there are three possible solutions for the linear programming problem: a unique solution at a vertex point, an infinite number of solutions between two vertices, or a nonsolution if the opportunity set is empty or unbounded.

One of the most important early discoveries in linear programming was the concept of duality and its many important ramifications (Gass, 1972). This discovery revealed that every linear programming problem is associated with a dual linear programming problem, which bears an important and special relationship to the original problem. Knowledge of this duality is used to study the effects of changes in the values of the parameters of the given problem. Also, it can be used to construct an alternative method for solving linear programming problems. If the original problem, called the primal, takes the form of (3.2)

$$\text{(3.3)} \quad \begin{aligned} &\text{maximize} \quad f(x) = C'X \\ &\text{subject to} \quad AX \leq b \\ &\qquad\qquad\quad x \geq 0 \quad , \end{aligned}$$

then the dual problem is the linear programming minimum problem

$$\text{(3.4)} \quad \begin{aligned} &\text{minimize} \quad f(y) = YB \\ &\text{subject to} \quad YA \geq c \\ &\qquad\qquad\quad y \geq 0 \quad , \end{aligned}$$

where Y is a vector row. Here both problems involve finding an extremum of a linear function by choice of non-negative variables subject to linear inequality constraints. The parameters in both problems are the same. However, the primal problem involves the choosing of n variables summarized by the vector X, whereas the dual problem involves choosing m variables summarized by the row vector Y. The constraint's constant of one problem becomes the objective constant of the other. In summary, the dual of the dual is the original problem.

A way to understand the nature of the dual problem is through the Lagrange multiplier of the primal problem (Intriligator, 1971). As discussed earlier, the first fundamental theorem of linear programming is the existence theorem which states that a necessary and sufficient condition for the existence of a solution to a linear programming problem is that the opportunity set of both problems, the primal and its dual, are non-empty. The fundamental theorems of linear programming are based on Lagrangian and Kuhn-Tucker conditions. Assuming the primal is a maximization problem such as (3.3)

$$\begin{aligned} \text{(3.5)} \qquad \text{maximize} \quad & f(x) = CX \\ \text{subject to} \quad & AX \leq b \\ & x \geq 0 \end{aligned}$$

then, according to the Kuhn-Tucker theorem. X^* (the optimal value of X) is a solution to (3.4) if such a row vector Y^* exists that for a Lagrangian function as

$$\text{(3.6)} \qquad L(x,y) = cx + y(b-Ax)$$

the following Kuhn-Tucker conditions hold a x^* and y^* (Intriligator, 1971)

$$\frac{\delta L}{\delta x} = c-yA \leq 0$$

$$\frac{\delta L}{\delta x}x = (c-yA)x = 0$$

(3.7) $$x \geq 0$$

$$\frac{\delta L}{\delta y} = b-Ax \geq 0$$

$$y\frac{\delta L}{\delta y} = y(b-Ax) = 0$$

$$y \geq 0$$

If, to the contrary, the primal linear programming problem has been a minimization problem, like (3.4)

(3.8) $$\begin{aligned} &\text{minimize} \quad f(y) = YB \\ &\text{subject to} \quad YA \geq c \\ &\qquad\qquad\qquad\; y \geq 0 \end{aligned}$$

then the Kuhn-Tucker theorem implies that y* is a solution if such a column vector X* exists that, when defining a Lagrangian function for the dual as

(3.9) $$L(y,x) = yb+(c-yA)$$

that then the following Kuhn-Tucker conditions hold an x* and y*

$$\frac{\delta L}{\delta y} = (b-Ax) \geq 0$$

$$y \frac{\delta L}{\delta y} = y(b-Ax) = 0$$

$$y \geq 0 \qquad (3.10)$$

$$\frac{\delta L}{\delta x} = (c-yA) \leq 0$$

$$\frac{\delta L}{\delta x} x = (c-yAx) = 0$$

$$x \geq 0$$

Thus, the Lagrangian and Kuhn-Tucker conditions are the same for both problems.

The second fundamental theorem of linear programming is the duality theorem which states that a necessary and sufficient condition for a feasible vector to represent a solution to a linear programming problem is that there exists a feasible vector for the dual problem for which the value of the objective function in both problems is the same. This is shown by the Kuhn-Tucker conditions discussed above.

The third theorem of linear programming is the complementarity slackness theorem, which states that a necessary and sufficient condition for feasible vectors x* and y* to solve the dual problem is that they satisfy the complementary slackness conditions

$$(3.11)\qquad (c-y^*A)x^* = 0$$
$$y^*(b-Ax^*) = 0$$

This follows directly from the Kuhn-Tucker conditions and the duality theorem (Intriligator, 1971). The variables of the dual problem are Lagrange multipliers for the primal problem and they can be interpreted as the sensitivity of the optimal of the objective function with respect to changes in the maximum availability of resources.

Previous Research

Previous studies to determine optimal land use and other resource allocations range from micro-models that focus at the farm level to large macro-models that cover an entire country. These models, regardless of the range of their focus, have been designed to study specific aspects of resource allocation, no matter if the allocation takes place in production, consumption or exchange activities.

Micro-models

Green (1974) developed a model to analyze efficient resource allocation on peasant farms. Green's study attempts to design a normative land use model at the individual farm level which specifies plans for maximizing the values of production within the limits set by the quality and availability of physical environmental resources, and by social and technological constraints. The paradigms of the man-land relation and spatial variation were used in an attempt to build models reflective of realities of the peasant farm in a local context. Green's main argument is that a peasant farm differs from its capitalist and socialist counterparts in that almost all labor is supplied by the household, earning not a salary, but requiring food and other necessities. This labor is regarded as a fixed cost regardless of its utilization. Therefore, the peasant farm may be regarded as an integrated unit in which the functions of production and consumption cannot be separated.

Using linear programming techniques, Green tries to maximize the value of farm production and to minimize family consumption cost for an adequate diet. The model is generated under different conditions. First, risk is ignored, then it is recognized and incorporated into the model. The results from this study show that revenues can be increased and that diet can be improved on most farms.

Lin, Dean and More (1974) tested the hypothesis that Bernoullian and lexicographic utility are more accurate predictors of farmers behavior than profit maximization. A sample of large California farms was used for hypothesis testing by developing income tax expectation variance (E-V) boundaries for each farm, and the results offered a set of utility and profit maximizing plans. In this study, production functions for individual crops were estimated. rather than for a heterogeneous aggregate. Technical and price risk for each crop also were included. The farmer's subjective attitude towards risk was approximated by estimation of utility functions. Using quadratic programming, the E-V frontier for each farm was derived by means of the following model:

$$\begin{aligned} \text{maximize} \quad & Z = C'X - 1/2X'QX \\ \text{subject to} \quad & AX \leq b \\ & C'X = k \\ & x \geq 0 \end{aligned}$$

with Z = objective function, X = column vector of acreage of individual crop, C' = row vector of expected net return per acre, 1/2Q = variance-covariance matrix of net returns of individual crops, A = matrix of input-output coefficients for each crop, b = vector of constraints and k = constant indicating expected net return, which was varied parametrically. A goodness-of-fit criterion showed that Bernoullian utility formulation provided the greatest accuracy in predicting actual and planned crop patterns. Profit maximization showed the poorest predictive power.

Yaron and Horowitz (1972) developed a model for the practical problem of planning a typical family farm in Southern Israel. The farm primarily was engaged in the production of irrigated field crops. Because of irrigation facilities, the government supports prices and well established technology; significant risk arises only when intensification of production is sought by producing out-of-season vegetables in plastic-walled houses which requires a high investment. The model used was a series of short-term plans which were solved for each year. This sequential programming model depicts the growth of the farm and the capital accumulation under uncertainty.

In a more traditional environment, Farrington (1977) analyzes the efficiency of Malawi's small-holders in allocating resources. This writer takes into account the availability of traditional (labor) as well as non-traditional (chemical fertilizer, insecticide) inputs. Farrington uses a production function of the Cobb-Douglas type and a neoclassical approach, and tries to determine how close small-holders come to the theoretical optimum in their resource allocation patterns. A general conclusion was that a serious deviation from the optimum use-level of a factor of production often can be explained by the unpredictable influence of weather. Small-holders exhibit a high degree of rationality by varying their use-level of insecticide to allow for the influence of weather on crop growth prior to the time of application. The unpredictability of weather forces small-holders to apply lower amounts of fertilizer than that which is required in good years and higher amounts than that which is required in poor years. This is explained in terms of the impossibility of predicting when "poor" or "good" rainfall will occur.

Dean and De Benedictis (1964) used dynamic linear programming to derive a normative development plan over time for small land reform farms in a newly irrigated region of southern Italy. A model was developed that allows specification of an optimum development pattern through time, which measures the productivity of government low interest loans, and which directs grants for actual development. The mathematical formulation of the model starts with a specification of the production function for the individual farm

$$Yt = f(Lt, Kt, Tt)$$

with Y = output of a single product, L = labor, K = capital stock, T = land and t = time. Net income in period t is specified as

$$\Pi t = PytYt = (PltLt + PktKt + PTtTt)$$

with P representing prices per unit of product and per factor in period t. Pk and Pt were considered as the prices of the annual services per unit of capital and land respectively. The objective of this model was to maximize the present value (PV) of the flow of future net income, t discounted at the rate r, subject to restrictions on the level of the resources available. It was assumed that capital stock equals previous capital stock plus net new investment (I). Then, investment was determined as

$$It = St - 1 = \quad t - 1 - Ct - 1$$

where $$Ct = f(\Pi t - 1),$$

with S = family savings and C = family consumption. Finally, noting that consumption is a function of previous income, and given the factor prices (P), the empirical specification of the production function and the consumption (C), and resources (L, K, T), the model provided a recursive form of farm growth over time. After solving the model, Dean and De Benedictis offered an optimal plan that reveals a tremendous potential for internal savings and investments on land reform farms.

Other studies carried out in developing countries at a micro-level coincide in examining problems related to the way of raising food output and the rationality of the decision-making process among farmers (Farrington, 1977;

Reid et al., 1980; Smith, 1975). The general conclusion has been that farmers in LDC's are rational in making decisions. However, output can be improved substantially by introducing small changes in the social and technical factors of production. As a general rule in developing countries, where extension of cultivated areas is possible today, a considerable increase in agricultural production could be achieved on family-farms through improvements in communication, transport and marketing. On the other hand, where expansion of the area under cultivation is not feasible, output must come mainly through improvements of techniques and organization at the farm level, which in turn leads to increases in productivity.

Macro-models

Large-scale, price exogenous linear programming models have been developed and used in many countries to simulate the impact of farm programs upon agricultural sectors (Duloy and Norton, 1975; Heady, 1971; Heady and Srivastava, 1975; Rochin, 1976). Most of these models assume fixed market prices and fixed quantities (Heady and Srivastava, 1975). Sector analysis models recognize price-quantity interrelationships and are useful in dealing with spatial equilibrium problems. Takayama and Judge (1963) extended the Samuelson formulation by using linear, price dependent demand and supply functions in such a way that the spatial structure of price, input use, production and consumption were determined with quadratic programming. Duloy and Norton (1975) used quadratic programming in the way of separable programming and developed a procedure for representing competitive and non-competitive market structures in linear programming models. These investigations arbitrarily chose close approximation to non-linear terms in both the objective function and the constraints set without losing much of the computational efficiency of the simplex algorithm. Then, they used the non-competitive market structure for measuring income and endogenous price in a competitive model. They also approximated product substitution effects in demand with the help of a linear program. The demand structure can be transformed to take account of any shift in demand which can be represented by rotation of the linear function.

Thorbecke (1973) provides a useful classification of the major types of agricultural models developed for developing countries, type A: multi-level planning; type B: micro-economic dynamics; type C: simulation; type D: general equilibrium.

Multi-level models are those which have the "district" levels in a spatial context as the basic units. These are linked to the regional level and then to the national level within the sector. Although such models are constructed through several levels, the basic unit is an aggregate of farm resources rather than of individual farms. The district is usually land area described in terms of total land, labor, capital, production techniques and so forth. It is essentially a disaggregation of the single national model rather than an aggregate of the basic micro-units, the farm.

Micro-economic dynamic models have a "button-up" formulation, starting from the farm as the unit of observation to reproduce farm level decision-making by assuming that the farmer's preference function is lexicographic. The main strength of this model for policy purposes is its ability to provide short and medium-term forecasts for a set of policies and to generate the time-path for a given policy (USDA, 1977).

Simulation models are by definition of the consistency rather than of the optimization type and have been used in Korea and Nigeria. They are composed of a series of submodels with functions that can be geographical, recursive or behaviorally independent.

The last type of model classified by Thorbecke is one defined as a "conceptual framework", and represents an informal approach to agricultural planning.

Risk and Uncertainty

Many economic principles are based upon the assumption that people are rational and that the future can be predicted with a specified degree of accuracy. Thus, in agriculture it is assumed that future yields, prices, and costs can be predicted. When budgets are made, these estimates for the future are very useful. However, it is known that they cannot be estimated with complete accuracy. This lack of perfect knowledge influences decision-making and creates uncertainty.

Knight (1921) outlined the degrees of knowledge that are logical possibilities. These categories (perfect knowledge, risk and uncertainty) encompass all logical possibilities. Risk is defined as the situation which exists when the future can be predicted with a specific degree of probability.

Freund (1956) analyzes the introduction of risk into a programming model by describing risky outcomes as probability distributions and choosing from among alternate possible distributions by the expected utility hypothesis. From the distribution of the net revenue of the unit level of various processes, a distribution is developed of the net revenue due to some program X. The revenue of each process is assumed to be normally distributed. By using an expected utility hypothesis, the farmer makes a choice from among a set of probability distributions. One such function could be

$$Y(r) = 1 - e^{a^{2}}$$

where Y = utility, r = net return, and a = risk adversion. This function is convex everywhere, therefore, the larger the value a, the more conservative the farmer. Freund used the function

$$E(u^*) = u - \frac{a}{2}\sigma^2$$

with u = expected revenue and σ^2= variance, to maximize the expected utility.

Two basic weaknesses have appeared in applying this method of incorporating risk. First, the deficiencies in choosing a value for the constant a, which measures the risk adversion degree of the farmer, and second, in the evaluation of the variances of net revenue.

In a programming model, the researcher is interested in obtaining the farmer's own estimates of the variability of prices and yields of individual crops, which is based on his past experience. However, in most cases incomplete memory of the farmers and lack of experience may arise with new crops that were of interest for the programming analysis.

More recently, Hazell (1976) developed a linear alternative to quadratic and semivariance programming for farm planning under uncertainty. The expected income variance (E-V) criterion of quadratic programming assumes that farmers hold preferences among a set of farm plans based solely on their expected income E associated with its variance V. This is so, if the farmer has an E-V utility function and if the farmer is risk adverse. This implies that along every iso-utility curve $dE/dV > 0$, the farmer would prefer a strategy with higher V only if E were also greater and $d^2E/d^2V > 0$ (compensation increases at increasing rate with increase in V). Markowitz (1952) analyzes the utility of income functions in this direction, when using these to study the process of portfolio selection.

When the basic source of risk is confined to yield, stochastic market prices are implied, because stochastic yield in agriculture implies stochastic supply functions, and hence, leads to stochastic market prices. However, input costs and market demand could be assumed to remain non-stochastic and the program constraints are not affected.

The Kuhn-Tucker conditions obtained from specifying the deterministic, individual producer case as a Lagrangian function, require that the marginal cost per unit of output must be equal to or greater than the price of that output for each product. Marginal cost is comprised of the Lagrangian multiplier representing the prices inputed to the purchased and owned factors of production. In the stochastic case, the Kuhn-Tucker conditions state that the expected marginal cost of purchased inputs, the expected marginal opportunity cost of production factors owned, and a marginal risk factor represent the additional expected return demanded by producers as compensation for taking risk.

Dillon and Scandizzo (1978) assessed risk attitudes of samples of small subsistence farmers and sharecroppers in northeastern Brazil. The farmers' risk attitudes were evaluated by their choices between hypothetical farm alternatives involving risk versus certain outcomes. The broad conclusion of this empirical study was that most, but not all, peasants were risk avertors. Risk aversion tends to be more common among small owners than among sharecroppers and the level of income and other socioeconomic variables influence peasants' attitudes toward risk.

Consumption and Nutrition Aspects

In most developing countries, the important issue is not only to increase agricultural production but to increase consumption and nutrition too. The world's small farmers are both producers and consumers of food products. Attempts to improve consumption levels and diets using mathematical programming have been made (Ahn et al, 1981; Green, 1974; Singh, 1973; Smith, 1974).

New approaches to consumer theory emphasize that utility is derived from the properties or characteristics of the goods and not from the goods themselves (Lancaster, 1966). Ladd and Suvannunt (1976) derived and tested two hypothesis concerning characteristics of purchased consumer goods. Prices paid by the consumer for each product consumed equal the sum of the marginal monetary value of the product's charcteristic, the marginal monetary value of each characteristic equaling the quantity of the characteristic obtained from each marginal unit of the product consumed multiplied by the marginal implicit price of the characteristic. Furthermore, consumer demand functions for consumer goods are affected by characteristics of the goods. Thus, the model of consumer goods' characteristics looks upon a product as a collection of characteristics. The study was based on issues involving product heterogeneity, such as product differentiation, quality, and grades and standards. From this point of view, the utility provided by the goods is a function of the characteristics of the product.

Smith (1974) analyzes the consequences of malnutrition in the process of economic development. His basic argument is that in the process of economic development, the agricultural sector shifts from subsistence agriculture to cash cropping, damaging the nutritional status of the rural population in the process. The harmful nutritional consequences of developing a market oriented agriculture can be minimized by development planning that takes into account nutritional well-being in addition to income. Also, a linear programming problem was formulated to determine the most economical set of food and production activities.

However, problems arose because the set of nutrients needed cannot be specified as a fixed quantity. The quantity of protein required by the human body depends upon the conciliation of protein in the diet and the quality of protein, which in turn depends on its amino-acid composition. Thus, the greater the concentration, the less efficient the protein is used, while the better the quality, the more efficient it is used. For a low cost diet, quality and quantity must be determined simultaneously. However, such programs must balance adequate nutrition with the sacrifice of income from cash crop production.

The Problem of Aggregation in Production.

Very few geographers have been willing to make use of linear programming models to analyze production processes of a region or a country. However, due to the advance of computer technology and the need for a better understanding of processes taking place in large geographical regions, geographers too have become involved in quantitative procedures. Agricultural economists have been using this technique very often during the last two decades, analyzing production processes in a spatial context (Ahn et al., 1981; Day, 1963; Day and Sparling, 1977; Goreux and Manne, 1973; Heady and Egbert, 1964).

The analyst who wishes to predict outcomes over space when many micro decision-making units are involved, as is the case in the Azua Region, must choose between micro and macro analytical techniques. In the first case, the farmer is the individual decision-maker and direct statistical quantifications can be made. In the second case, only a statistical estimate of the aggregate of individual units is possible. It is the transition from the farm level to the regional level or even the national level that creates the problem when aggregating.

Some questions may arise when dealing with aggregation in linear programming,. One of the most important ones was posed by Day (1963, p.798) two decades ago: "To what extent must the component firms be alike in order for the single model to represent the aggregate of the individual decision problem without distortion?". In the same article Day tries to show that a single linear programming model can be sufficient, under suitable conditions, for the aggregation of the solution of a set of individual unit models. Day stated that these conditions are a) a proportional variation of resources; b) a proportional variation of next return expectation; and c) that the matrix of technical coefficients in every firm must be identical to the matrix of the aggregation model. Later, Marenco (1969) showed the redundancy of Day's condition b above. More recently, Spreen and Takayama (1980) concluded that the possibility of constructing an exact aggregation model in an empirical study is remote. They introduced the term "semi-exact" aggregation to show that, under restrictive conditions, a semi-exact aggregation model can be constructed.

In the Azua region, similarity of endowed resources among farm-households provides an ideal condition for aggregation. In this study an aggregation attempt was made taking into account the above discussed limitations.

CHAPTER IV

NORMATIVE FARMLAND PLANNING MODEL FOR THE NEWLY IRRIGATED AZUA PLAIN AND ITS FARM-HOUSEHOLDS

Agricultural land use planning at a national scale should be the sum of all regional plans in a country and represent, in a sense, the final stage in the planning process. Initial farm level planning must be undertaken at the topographic scale and should account for spatial variations in the agro-socioeconomic conditions present on the landscape. Farm production is intimately related with climate, soils, slope and local socioeconomic conditions. These factors determine the method and extent of the application of advanced agronomic techniques. An effective farm plan for agricultural development, therefore, must take into account variations in agro-socio-economic conditions from farm to farm. Adoption of a generalized scheme that ignores such local variations may lead to project failure and financial catastrophe for the respective small farmer.

A farm plan is concerned with identifying the resources available to the individual farmer and prescribing the level of agricultural activities which will give the farmer an optimal allocation of resources in terms of his pre-established goals. A regional plan is concerned with the same problems but at a broader level. It is assumed that the information needed about local agricultural problems already is available at the time the plan is formulated. Information from local surveys, therefore, plays an important role in this micro-planning process. A special sampling survey was conducted in the Azua region at the farm level to achieve this end.

Data Collection

Fieldwork was conducted in a series of phases. An initial three month reconnaissance was made in the summer of 1980 to provide a basis for problem identification. General information was collected and a preliminary report was prepared describing the region (Perez-Luna, 1980). A systematic field survey was conducted during June and July 1982 with assistence from SEA. The objectives of this survey were twofold: to provide the investigator with first-hand experience concerning the reality of family-farm operations in the region, and thereby ensure a more realistic assessment of the study's findings; and to collect specific information for model calibration regarding farm operations and the farm environment.

The first objective was achieved by conversing with farmers, agronomists, extension agents and planners working in the region, by personally observing the farmers' way of life and by gathering data from secondary sources. The second objective was fullfilled by carrying out structured interviews with selected farmers using a prepared questionnaire. Data obtained through the interview process included land utilization, ownership, soil type, production and input costs, capital, management, technology, social characteristics of the family, and family income. The questionnaire was precoded for computer processing. Data concerning consumption and nutrition were obtained from other primary sources (Banco Central, 1982) and information regarding nutrition was made available by the Secretariat of State for Public Health and ONAPLAN.

Sample Design and Farm Classification

A stratified random sample design was used to select the farms for study. From the total population, N = 7591 parcels, registered and mapped by the National Catastral Survey Department, a sample of Ni = 200 was drawn. The 7591 parcels cover the entire municiplaity of Azua.

The sample was drawn as follows. The total population (N) was divided into sub-populations or strata according to farm size (n1, n2, ..., n10 units). These sub-populations were non-overlapping and together they comprised the entire population, so that

$$n1 + n2 + \ldots + n10 = N = 7591$$

A sample from each strata was drawn, once the strata were determined, taking into account the frequency of observation and the variance of each strata. The selection was made independently for each strata so that

$$n1 + n2 + \ldots + n10 = Ni = 200$$

Because precise data were needed for the lower strata of the population, each subdivision was treated as a population in its own right. This procedure made estimating characteristics of the whole population more precise and made possible the selection of internally homogeneous sub-populations (Cochran, 1977).

The total population (N), grouped according to farm size, is presented in table 4.1. Because interest focused on small farms, which represent more than 90 percent of rural land holdings in the study region, the following three areal sizes were discriminated for analysis 0-63, 64-95 and 96-159 tareas (1 tarea = 625 square meters). The average amount of arable land assumed to be available for crop production for each group respectively is 25, 60 and 125 tareas.

Table 4.1: Basic Data for Sampling Design. Total Parcel Population in the Azua District, Dominican Republic.

Strata (tareas)	Frequency (N)	Accumulated frequency	%	Mean (x)	Variance (s)
0 - 31	3595	3595	47	15.42	4.13
32 - 63	1617	5266	69	44.99	5.09
64 - 95	726	6028	79	76.46	5.25
96 - 159	609	6637	87	122.27	19.87
160 - 319	538	7175	94	221.80	115.91
320 - 639	226	7401	97	423.57	438.04
640 - 1279	115	7516	99	882.29	2293.42
1280 - 1919	24	7540	99.3	1518.45	1738.98
1920 - 3199	20	7560	99.5	2361.67	9060.77
3200 & more	31	7591	100	49,862.88	8.9928768E

Azua farmers, like those in most irrigated low latitude areas, have a number of field crop alternatives from which to choose as they allocate their land, family labor, water and capital resources. Although there are slight variations in seasonal temperatures, vegetative growth is continuous throughout the year, making double and even triple cropping possible. In general, cereals, staples, oil seeds, food legumes, and perennial crops (plantain, banana, pineapple, avocado, mango) compete with each other during the whole year for the farmer's scarce resources.

Irrigation water in the Azua plain, in addition to making a variety of crop combinations possible, also conditions the farmers' decision-making process. Irrigation changes markedly the degree of technical uncertainty associated with input-output relationships. This uncertainty about expected crop yields is reduced substantially when water does not depend on rainfall. In the case of Azua, a typical farm primarily is involved in the production of irrigated field crops. The technology of production, although different for each crop, is well established. For example, tomatoes grown for processing (by the local canning factory) ask for a specific technological package that must be used by any farmer growing these tomatoes. Irrigation eliminates weather uncertainty, and the prices of the major grain crops are kept fixed by government controls. Therefore, there is little risk involved in producing these major crops. With no undue loss of reality, the factor risk will be regarded as neglegible. However, the income generated by this type of production is low. Ways of intensifying production include short cycle multicropping and selecting an optimal crop mix.

This combination of environmental and agronomic conditions found in the Azua plain are complicated further by the introduction of irrigated agriculture and favor the use of analytical techniques like linear programming to analyze optimal resource allocations at the farm and regional levels. Based on the general conditions prevailing in Azua that have been described in chapter I, the activities and constraints of the model are presented in detail in the following sections.

Analytical Model

A dynamic linear programming (DLP) model was designed to analyze behavior patterns within the three categories of small farmers. Optimum land use, production, consumption and marketing program components were determined endogenously, subject to a set of production constraints and nutrient requirements for representative farm-households within each small farm category. The procedure was followed at the regional level. The models contain 273 activities (columns) and 161 constraints. The basic model was formulated on a four-month growing season which was linked recursively to the agricultural year.

Since the literature on LDC economies suggests that farmer objectives cannot be depicted accurately by a single profit maximization equation in a neoclassical sense, two objective functions were used to capture possible farmers' objectives which then were evaluated on an individual basis. Several slightly different formulations of the basic DLP model were used to simulate the effects of alternative farm size, technology level, soil quality and crop mix. Differences and similarities in the characteristics of each model are discussed in the following sections.

Coverage

The model is limited to major short-cycle crops grown on the Azua plain such as corn, rice, beans, manioc, peanuts and tomatoes. Plantain was the only perennial crop included because of its importance in the region, both as a cash crop and for home consumption.

Livestock was not included since the field survey indicated that the farm animal population was limited mainly to goats, farmyard chickens and an occasional milk cow. The only important livestock operation in the region is one just being initiated by the Agrarian Reform Institute.

The models cover production at the farm and regional levels. No processing activities were included since none were reported by the field survey.

Structure

The farm-household model describes the behavior of a semi-commercial family farm within a competitive labor market. The type of farm studied is situated within a continuum between a wholly commercial farm employing solely hired labor and marketing all inputs and outputs, and an essentially subsistence farm using only family labor and producing solely for home consumption (chapter II, p.33).

The planning period is assumed to be a farm production season of four-months duration. The model is recursive and repeats the quarterly production cycle to fit the agricultural year which is the planning horizon. It is assumed that the area under production and crop yield remain the same for each quarter of the agricultural year cycle since all farms are situated within the irrigated area and production is not influenced by fluctuations in the annual distribution of precipitation. Decisions relating to family labor supply and land use are held constant. It is assumed that household labor is hired in and out at the going market rate, and that the household is a price taker with respect to output and input markets, that there are no sharecroppers and that land rents are fixed. The model focuses on short-run determinants of the various production and consumption activities.

A plan for each period emerges from a single optimization. Capital available during any production period is estimated within the model, thus resolving the dilemma whether capital availability is a function of income or vice-versa. Each restraint appears in a separate row for each production period. Activities likewise are specified by time periods; thus bean production t1 (bean in the first period) is an activity different from bean production t2 (bean in the second period) and in t3. Provisions are made to transfer capital from one period to another. The structure of the dynamic model is schematically illustrated in figures 4.1 and 4.2.

Objective Functions

The objective functions are as follows:

(4.1) maximize expected return =

$$\sum_{t=1}^{3} \{ \sum_{i=1}^{74} (piSi + kpiI + aiLi - rBj - cili) - \sum_{j=1}^{29} eiFj \}$$

(4.2) maximize

$$\text{total output} = \sum_{t=1}^{3} \sum_{i=1}^{14} piSi$$

where ai = discounted expected return from crops not actually harvested in the base model (in pesos)
Bj = borrowed capital (in pesos)
ci = variable cost per land unit (in pesos)
ej = retail food price (in pesos/lbs)
Fj = food purchase vector (in pounds)
I = stored production held for the next production period (in quintal)
k = weight factor
Li = crop activity level vector (in tarea)
pi = price received by farmers (in pesos)
r = interest rate (in pesos)
Si = sale vector (quantity in quintal)

Equation (4.1) singles out the goals of expected return (ER) maximization. This equation tries to capture the objective of a farmer who envisions the operation of an integrated enterprise in which the family's nutritional need plays an important role. In this type of model the integration of production and consumption is fully accomplished through the specification of the family's nutritional requirement together with production requirements in such a way that production, distribution and consumption are interdependent activities. In this case, farmland use and other resource allocations depend not only on the market forces, but also on the farm-household food needs. Expected return is evaluated as a measure of profit maximizing behavior.

Equation (4.2) tries to capture the behavior of farmers who are more interested in maximizing the market value of the total output. This goal is understandable if one considers those farmers whose immediate goal is to maximize the cash earnings. This total output has been estimated at market value.

Activity Sets

Representative family farms in the Azua region are assumed to be engaged in a set of six different activities which are crop production, consumption, sale, storage, labor supply and finances.

Crop Production. Production activities (CPA) define the transformation of factor inputs into crop production. They represent the individual farm-family supply in the representative farm-families or the regional supply of production. Each activity is represented by a series of vectors for alternative land use potentials and available levels of technology, with each crop vector having yield and input computed on a per tarea basis. The entries in the objective function are the variables defined in the equations (4.1) and (4.2).

Differentiation among the model's CPAs is aimed at determining its analytical use in the decision-making process. Different levels of technology are employed through the use of factor input disaggregations for each production activity. Coefficients of production activities were estimated from the field survey data.

Three representative types of small farms were selected according to three different technology levels and two different soil types. All production is transferred to selling, home consumption or storage for future disposal.

Fourteen crops were selected for initial simulations based on the crop's present importance in the region or its future potential as a cash crop. Each crop was disassociated according to the technology level and the type of soil used as shown in table 4.2. The first subscript refers to the soil type (1 or 2). The second subscript refers to the technology level (1,2 or 3) and the third subscript refers to the period of the planning horizon (none, 2 or 3). The classifications will be explained in the following paragraphs.

Farms were stratified according to the degree of presence or absence of key factors, which are held responsible for different production systems and differences in production costs and yields. The factors singled out for this purpose were planting system (use or non use of seedbeds), irrigation (use of gravity, pump or aspersion system), use of modern inputs (reflected in the input coefficients i.e. chemical fertilizers, pesticides, herbicides), land preparation (manual, animal draft, semi-mechanized, fully mechanized), and potential land productivity (soil classes i to iv, suitable for crop production, pasture and forest, OAS, 1967).

Criteria used to classify level of technology were those used by SEA's farm management unit (SEA, 1982). As an example, modern input level was classified low if the farmer used less than 40 percent of each chemical recommended by the extension agency, medium if the farmer used from 40 to 75 percent, and high if the farmer used more than 75 percent.

Land quality affects the production costs of each enterprise and thus was included when determining the production system. As stated in chapter I, the land classification system put forward by the OAS (1967) was used. The subscripts 1 and 2 refer to land types A and B respectively.

The presence of monthly land constraints allows for the determination of multi-cropping patterns within the model. Thirty-five crop activities were considered in the basic model for the first period of the planning horizon.

Table 4.2: Description and Unit of Measurement for CPAs of the Dynamic Linear Progamming Model.

Code(*)	Code description	Unit
Corn13	Corn production activity, first period	tarea
Corn21	Corn production activity, first period	tarea
Corn23	Corn production activity, first period	tarea
Sorg11	Sorghum production activity, first period	tarea
Sorg12	Sorghum production activity, first period	tarea
Sorg13	Sorghum production activity, first period	tarea
Sorg23	Sorghum production activity, first period	tarea
Rice11	Rice production activity, first period	tarea
Rice12	Rice production activity, first period	tarea
Rice13	Rice production activity, first period	tarea
Rice23	Rice production activity, first period	tarea
Rbea11	Red bean production activity, first period	tarea
Rbea12	Red bean production activity, first period	tarea
Rbea13	Red bean production activity, first period	tarea
Bbea12	Black bean production activity, first period	tarea
Bbea13	Black bean production activity, first period	tarea
Bbea21	Black bean production activity, first period	tarea
Gand11	Pigeon pea production a period	tarea
Gand13	Pigeon pea production activity, first period	tarea
Gand23	Pigeon pea production activity, first period	tarea
Plan13	Plantain production activity, first period	tarea
Plan23	Plantain production activity, first period	tarea
Yuc13	Manioc production activity, first period	tarea
Yuc23	Manioc production activity, first period	tarea
Pep12	Green pepper production activity, first period	tarea
Pep23	Green pepper production activity, first period	tarea
Okr12	Okra production activity, first period	tarea
Okr13	Okra production activity, first period	tarea
Mel13	Melon production activity, first period	tarea
Tom13	Tomato production activity, first period	tarea
Tom23	Tomato production activity, first period	tarea
Pea13	Peanut production activity, first period	tarea
Pea21	Peanut production activity, first period	tarea
Pea23	Peanut production activity, first period	tarea
Scorn	Sale of corn, first period	quintal
Ssorg	Sale of sorghum, first period	quintal
Srice	Sale of rice, first period	quintal
Srbea	Sale of red beans, first period	quintal
Sbbea	Sale of black beans, first period	quintal
Sgand	Sale of pigeon peas, first period	quintal
Splan	Sale of plantain, first period	quintal
Syuc	Sale of manioc, first period	quintal
Spep	Sale of green pepper, first period	quintal
Sokr	Sale of okra, first period	quintal
Smel	Sale of melon, first period	quintal
Spea	Sale of peanuts, first period	quintal

Table 4.2 continued

Code(*)	Code description	Unit
Lsapri	Labor sale in April, first period	man-day
Lsmay	Labor sale in May, first period	man-day
Lsjun	Labor sale in June, first period	man-day
Lsjul	Labor sale in July, first period	man-day
Lhapri	Labor hired in April, first period	man-day
Lhmay	Labor hired in May, first period	man-day
Lhjun	Labor hired in June, first period	man-day
Lhjul	Labor hired in July, first period	man-day
Ccorn	Consumption of corn,.first period	quintal
Crice	Consumption of rice,.first period	quintal
Crbea	Consumption of red beans,.first period	quintal
Cbbea	Consumption of red benas,.first period	quintal
Cgand	Consumption of pigeon peas, first period	quintal
Cplan	Consumption of plantain,.first period	quintal
Cyuc	Consumption of manioc, first period	quintal
Cpep	Consumption of green pepper, first period	quintal
Cokr	Consumption of okra, first period	quintal
Cmel	Consumption of melon,.first period	quintal
Cpea	Consumption of peanuts,.first period	quintal
Stcorn	Storage of corn,.first period	quintal
Stsorg	Storage of sorghum, first period	quintal
Strice	Storage of rice,.first period	quintal
Strbea	Storage of red beans,.first period	quintal
Stbbea	Storage of black beans,.first period	quintal
Stgand	Storage of pigeon peas,.first period	quintal
Capbor1	Capital borrowed,.first period	pesos
Captra	Capital transferred, first period	pesos
Frice	Rice purchased,.first period	lbs
Fpast	Pasta purchased,.first period	lbs
Fcorn	Corn purchased,.first period	lbs
Fbread	Bread purchased, first period	lbs
Fspot	Sweet potatoes purchased, first period	lbs
Fpot	Potatoes purchased, first period	lbs
Fyuc	Manioc purchased, first period	lbs
Fsug	Sugar purchased,.first period	lbs
Fbean	Beans purchased, first period	lbs
Fgarl	Garlic purchased, first period	lbs
Foni	Onions purchased,.first period	lbs
Fban	Bananas purchased, first period	lbs
Fplan	Plantain purchased, first period	lbs
Fbeef	Beef purchased, first period	lbs
Fpork	Pork purchased,.first period	lbs
Fchic	Chicken purchased, first period	lbs
Fegg	Eggs purchased, first period	lbs
Farren	Herring purchased, first period	lbs
Fcodf	Codfish purchased, first period	lbs
Fsard	Sardine purchased, first period	lbs
Fmilk	Milk purchased,.first period	lbs
Fdmilk	Dried milk purchased,.first period	lbs

Table 4.2 continued

Code(*)	Code Description	Unit
Foil	Oil purchased, first period	lbs
Fsalt	Salt purchased, first period	lbs
Ftomp	Tomato paste purchased, first period	lbs
Fcoff	Coffee purchased, first period	lbs
Fchee	Cheese purchased, first period	lbs
Fbut	butter purchased, first period	lbs
Fcoc	Coconut purchased, first period	lbs
Corn132	Corn production activity, second period	tarea
Corn212	Corn production activity, second period	tarea
Corn232	Corn production activity, second period	tarea
Sorg112	Sorghum production activity, second period	tarea
Sorg122	Sorghum production activity, second period	tarea
Sorg132	Sorghum production activity, second period	tarea
Sorg232	Sorghum production activity, second period	tarea
Rice112	Rice production activity, second period	tarea
Rice122	Rice production activity, second period	tarea
Rice132	Rice production activity, second period	tarea
Rice232	Rice production activity, second period	tarea
Rbea112	Red bean production activity, second period	tarea
Rbea122	Red bean production activity, second period	tarea
Rbea132	Red bean production activity, second period	tarea
Rbea232	Red bean production activity, second period	tarea
Bbea122	Black bean production activity, second period	tarea
Bbea132	Black bean production activity, second period	tarea
Bbea212	Black bean production activity, second period	tarea
Bbea232	Black bean production activity, second period	tarea
Gand112	Pigeon pea production activity, second period	tarea
Gand132	Pigeon pea production activity, second period	tarea
Gand232	Pigeon pea production activity, second period	tarea
Pep122	Green pepper production activity, second period	tarea
Pep232	Green pepper production activity, second period	tarea
Oni132	Onion production activity, second period	tarea
Oni122	Onion production activity, second period	tarea
Okr122	Okra production activity, second period	tarea
Okr132	Okra production activity, second period	tarea
Mel132	Melon production activity, second period	tarea
Pea132	Peanut production activity, second period	tarea
Pea212	Peanut production activity, second period	tarea
Pea232	Peanut production activity, second period	tarea
Scorn2	Sale of corn, second period	quintal
Ssorg2	Sale of sorghum, second period	quintal
Srice2	Sale of rice, second period	quintal
Srbea2	Sale of red beans, second period	quintal
Sbbea2	Sale of black beans, second period	quintal
Spep2	Sale of green peppers, second period	quintal
Soni2	Sale of onions, second period	quintal
Sokr2	Sale of okra, second period	quintal
Smel2	Sale of melon, second period	quintal
Spea2	Sale of peanuts, second period	quintal

Table 4.2 continued

Code(*)	Code Description	Unit
Lsaug	Labor sale in August, second period	man-day
Lssep	Labor sale in September, second period	man-day
Lsoct	Labor sale in October, second period	man-day
Lsnov	Labor sale in November, second period	man-day
Lhaug	Labor hired in August, second period	man-day
Lhsep	Labor hired in September, second period	man-day
Lhoct	Labor hired in October, second period	man-day
Lhnov	Labor hired in November, second period	man-day
Ccorn2	Consumption of corn, second period	quintal
Crice2	Consumption of rice, second period	quintal
Crbea2	Consumption of red beans, second period	quintal
Cbbea2	Consumption of black beans, second period	quintal
Cpep2	Consumption of green peppers, second period	quintal
Coni2	Consumption of onions, second period	quintal
Cokr2	Consumption of okra, second period	quintal
Cmel2	Consumption of melon, second period	quintal
Cpean2	Consumption of peanuts, second period	quintal
Stcorn2	Storage of corn, second period	quintal
Strice2	Storage of rice, second period	quintal
Strbean2	Storage of red beans, second period	quintal
Stbbean2	Storage of black beans, second period	quintal
Stgand2	Storage of pigeon peas, second period	quintal
Captra2	Capital transferred, second period	pesos
Frice2	Rice purchased, second period	lbs
Fpast2	Pasta purchased, second period	lbs
Fcorn2	Corn purchased, second period	lbs
Fbread2	Bread purchased, second period	lbs
Fspot2	Sweet potatoes purchased, second period	lbs
Fpot2	Potatoes purchased, second period	lbs
Fyuc2	Manioc purchased, second period	lbs
Fsug2	Sugar purchased, second period	lbs
Fbean2	Beans purchased, second period	lbs
Fgarl2	Garlic purchased, second period	lbs
Foni2	Onions purchased, second period	lbs
Fban2	Bananas purchased, second period	lbs
Fplan2	Plantain purchased, second period	lbs
Fbeef2	Beef purchased, second period	lbs
Fpork2	Pork purchased, second period	lbs
Fchic2	Chicken purchased, second period	lbs
Fegg2	Eggs purchased, second period	lbs
Farren2	Herring purchased, second period	lbs
Fcodf2	Codfish purchased, second period	lbs
Fsard2	Sardine purchased, second period	lbs
Fmilk2	Milk purchased, second period	lbs
Fdmilk2	Dried milk purchased, second period	lbs
Foil2	Oil purchased, second period	lbs
Fsalt2	Salt purchased, second period	lbs

Table 4.2 continued

Code(*)	Code Description	Unit
Ftomp2	Tomato paste purchased, second period	lbs
Fcoff2	Coffee purchased, second period	lbs
Fchee2	Cheese purchased, second period	lbs
Fbut2	Butter purchased, second period	lbs
Fcoc2	Coconut purchased, second period	lbs
Corn133	Corn production activity, third period	tarea
Corn233	Corn production activity, third period	tarea
Corn213	Corn production activity, third period	tarea
Sorg113	Sorghum production activity, third period	tarea
Sorg123	Sorghum production activity, third period	tarea
Sorg133	Sorghum production activity, third period	tarea
Sorg233	Sorghum production activity, third period	tarea
Rbea113	Red bean production activity, third period	tarea
Rbea123	Red bean production activity, third period	tarea
Pep123	Green pepper production activity, third period	tarea
Pep233	Green pepper production activity, third period	tarea
Okr123	Okra production activity, third period	tarea
Okr133	Okra production activity, third period	tarea
Tom133	Tomato production activity, third period	tarea
Tom233	Tomato production activity, third period	tarea
Pea133	Peanut production activity, third period	tarea
Pea213	Peanut production activity, third period	tarea
Pea233	Peanut production activity, third period	tarea
Scorn3	Sale of corn, third period	quintal
Ssorg3	Sale of sorghum, third period	quintal
Srice3	Sale of rice, third period	quintal
Srbea3	Sale of red beans, third period	quintal
Sbbea3	Sale of black beans, third period	quintal
Sgand3	Sale of pigeon peas, third period	quintal
Spep3	Sale of green peppers, third period	quintal
Sokr3	Sale of okra, third period	quintal
Stom3	Sale of tomatoes, third period	quintal
Spea3	Sale of peanuts, third period	quintal
Lsdec	Labor sale in December, third period	man-day
Lsjan	Labor sale in January, third period	man-day
Lsfeb	Labor sale in February, third period	man-day
Lsmar	Labor sale in March, third period	man-day
Lhdec	Labor hired in December, third period	man-day
Lhjan	Labor hired in January, third period	man-day
Lhfeb	Labor hired in February, third period	man-day
Lhmar	Labor hired in March, third period	man-day
Ccorn3	Consumption of corn, third period	quintal
Crice3	Consumption of rice, third period	quintal
Cgand3	Consumption of pigeon peas, third period	quintal
Cpep3	Consumption of green peppers, third period	quintal
Coni3	Consumption of onions, third period	quintal
Cokr3	Consumption of okra, third period	quintal
Ctom3	Consumption of tomatoes, third period	quintal
Cpean3	Consumption of peanuts, third period	quintal

Table 4.2 continued

Code(*)	Code description	Unit
Trancap3	Capital transferred, third period	pesos
Capinv	Capital inventory, third period	pesos
Frice3	Rice purchased, third period	lbs
Fpast3	Pasta purchased, third period	lbs
Fcorn3	Corn purchased, third period	lbs
Fbread3	Bread purchased, third period	lbs
Fspot3	Sweet potatoes purchased, third period	lbs
Fpot3	Potatoes purchased, third period	lbs
Fyuc3	Manioc purchased, third period	lbs
Fsug3	Sugar purchased, third period	lbs
Fbean3	Beans purchased, third period	lbs
Fgarl3	Garlic purchased, third period	lbs
Foni3	Onions purchased, third period	lbs
Fban3	Bananas purchased, third period	lbs
Fplan3	Plantain purchased, third period	lbs
Fbeef3	Beef purchased, third period	lbs
Fpork3	Pork purchased, third period	lbs
Fchic3	Chicken purchased, third period	lbs
Fegg3	Eggs purchased, third period	lbs
Farren3	Herring purchased, third period	lbs
Fcodf3	Codfish purchased, third period	lbs
Fsard3	Sardine purchased, third period	lbs
Fmilk3	Milk purchased, third period	lbs
Fdmilk3	Dried milk purchased, third period	lbs
Foil3	Oil purchased, third period	lbs
Fsalt3	Salt purchased, third period	lbs
Ftomp3	Tomato paste purchased, third period	lbs
Fcoff3	Coffee purchased, third period	lbs
Fchee3	Cheese purchased, third period	lbs
Fbut3	Butter purchased, third period	lbs
Fchoc3	Chocolate purchased, third period	lbs
RHS23	Right hand side	

(*) First digit in the code refers to land type: 1 = land A, 2 = land B;
second digit refers to the technology level: 1 = low, 2 = medium, 3 = high technology level;
third digit refers to the time period: no digit = first period, 2 = second period, 3 = third period.

Consumption activities. This activity set allows for the household's share of the farm output and for retail purchase of food products. The basic model included 13 home consumption activities and 29 purchased food products. Table 4.3 lists the latter products and their nutrient content. Home consumption activities vary according to the crops planted in each planning period.

Figure 4.1 presents the matrix format of the dynamic linear programming model. Figure 4.2 shows a schematic picture of the matrix for the first period; periods 2 and 3 are structured in the same fashion with slight changes in the rows and columns.

Sales activities. Farm products were assumed to be sold right after the harvest or stored for future disposition. The market price for each commodity was determined exogenously. Income from the sale of farm products was available for investment in the next period but not during the same period. Twelve crop sales activities and 4 labor sales activities were considered in the first period of the planning horizon.

Table 4.3: Composition of Foods in the Edible Portion of one Pound, as Purchased.

Food	Calorie	Protein (g)	Fat (g)	Carbo Hydrates (g)	Calcium (mg)
Rice	1647	30.4	1.8	364.7	109
Pasta	1674	56.7	5.54	341.1	122
Corn	1651	35.8	5.4	355.6	27
Bread	1220	39.5	14.5	288.6	318
Sweet potato	440	4.9	1.5	103.2	128
Potato	316	7.7	0.4	73.3	31
Manioc	493	4.1	1.0	119.4	112
Sugar	1746	0	0	451.3	0
Bean	1529	99.0	7.3	258.8	390
Garlic	547	22.6	0.9	123.0	126
Onion	164	5.9	0.8	38.0	135
Banana	319	4.1	0.6	83.3	23
Plantain	413	3.8	0.3	110.5	25
Beef	1021	66.7	80.0	0	38
Pork	1827	36.3	185.2	0	21
Chicken	524	56.1	31.5	0	43
Egg	658	52.1	46.4	3.6	218
Herring	293	60.9	3.7	0	1596
Codfish	1018	153.1	5.8	0	(193)
Sardine	1411	93.4	110.7	2.7	1606
Milk	295	15.9	15.9	22.7	540
Dry milk	2295	117.9	136.1	154.2	3892
Cooking oil	4010	0	453.0	0	0
Salt	0	0	0	0	1148
Tomato paste	372	15.4	1.8	84.4	122
Coffee	0254	36.3	0	27.2	136
Cheese	1175	113.4	140.4	9.1	3175
Butter	3248	2.7	367.4	1.8	68
Chocolate	2395	20.0	159.2	262.6	426
Recommended dietary allowance	2400	55.1	68.0	432.5	592.1

Table 4.3 continued

Food	Iron (mg)	Vitamin A (mcg)	Thiamin (mg)	Ribo-flavin (mg)	Niacin (mg)	Vitamin C (mg)
Rice	3.6	0	0.32	0.12	7.2	0
Pasta	5.9	0	0.42	0.29	0.77	0
Corn	5.0	200	0.46	0.23	4.0	0
Bread	3.2	0	0.31	0.36	5.0	0
Sweet potato	3.8	40	0.38	0.19	2.3	87
Potato	2.7	0	0.39	0.12	5.4	39
Manioc	2.4	0	0.20	0.10	2.0	122
Sugar	0.5	0	0	0	0	
Bean	34.0	5	2.45	0.86	9.5	14
Garlic	6.0	5	0.90	0.34	2.6	38
Onion	2.1	5	0.13	0.17	0.8	38
Banana	2.6	2.75	0.12	0.06	1.7	90
Plantain	2.5	390	0.22	0.13	1.6	88
Beef	8.0	40.0	0.23	0.61	14.1	0
Pork	5.3	(o)	11.77	0.42	9.4	0
Chicken	4.6	(60)	0.25	0.49	29.7	0
Egg	9.3	(505)	0.42	120	0.2	0
Herring	2.4	0	0.03	0.27	12.6	0
Codfish	11.6	0	0.31	2.31	11.6	0
Sardine	15.9	21.15	0.10	0.74	20.1	0
Milk	0.5	180	0.18	0.82	0.5	0
Dry milk	3.2	1635	1.13	5.67	18	0
Cooking oil	0	0	0	0	0	0
Salt	0	0	0	0	0	0
Tomato paste	15.9	1500	0.88	0.54	14.2	221
Coffee	4.5	0	0	0.05	122.5	0
Cheese	4.5	1905	0.05	2.04	0.5	0
Butter	0	4.36	0	0	0	0
Chocolate	6.4	60	0.11	0.64	1.5	0
Recommended dietary allowance	19.5	1090.4	1.24	1.11	12.28	188.42

Source: Food Composition Table, Caribbean Food and Nutrition Institute, Kingston, Jamaica, 1974; and ONAPLAN, 1980.

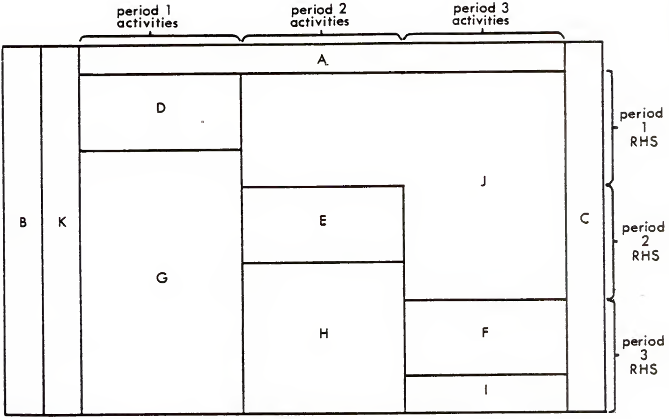

FIGURE 4·1: ORGANIZATION OF THE DYNAMIC LINEAR PROGRAMMING MODEL'S ACTIVITY MATRIX

A = identification of activities (columns)
B = identification of constraints or balance equations (rows)
C = maximum availability of resources (RHS)
D = input-output sub-matrix, period 1
E = input-output sub-matrix, period 2
F = input-output sub-matrix, period 3
G = distribution and transfer rows, period 1
H = distribution and transfer rows, period 2
I = distribution and transfer rows, period 3
J = all matrix elements to the right of main diagonal are zero
K = type of constraint (E = equal; L = less than or equal to; G = greater than or equal to; N = no constraint)

CONSTRAINTS	35 CROPPING ACTIVITIES	13 HOME CONSUMPTION ACTIVITIES	14 SALE ACTIVITIES	6 STORAGE ACTIVITIES	8 LABOR ACTIVITIES	2 FINANCIAL ACTIVITIES	29 FOOD PURCHASE ACTIVITIES	RHS
OBJECTIVE	$C_1X_1 \cdots C_{25}X_{35}$	$W_1 \cdots W_{13}$	$P_1S_1 \cdots P_{14}S_{14}$	$Q_1 \cdots Q_n$	$A_1L_1 \cdots A_8L_8$	$0\ 12T_1 \cdots T_2$	$E_1F_1 \cdots E_{29}F_{29}$	
4 LAND A CONSTRAINTS	$1\ 1 \cdots 1$ $1 \cdots 1$							$\le L_1$ $\le L_4$
4 LAND B CONSTRAINTS	$1 \cdots 1$ $1 \cdots 1$							$\le L_1$ $\le L_4$
4 LABOR CONSTRAINTS	$N_{1,1} \cdots N_{1,35}$ $N_4 \cdots N_{435}$				$1 \ddots -1$			$\le F_1$ $\le F_4$
14 DISTRIBUTION EQUATIONS	$-\Sigma Q_{ij} \ddots -\Sigma Q_{ij}$	$1 \ddots 1$	$1 \ddots 1$	$1 \ddots 1$				≤ 0 ≤ 0
11 NUTRIENT CONSTRAINTS		$K_{1,1} \cdots K_{1,13}$ $K_{11,1} \cdots K_{11,13}$					$K_{1,1} \cdots K_{1,29}$ $K_{11,1} \cdots K_{11,29}$	$\ge RDA$ $\ge RDA$
2 FINANCIAL CONSTRAINTS	$C_1 \cdots C_{35}$		$-S_1 \cdots -S_{14}$		$-A \cdots A$	$-1\quad 1$ 1	$T \cdot\cdot T \cdots T$	≤ 0 $\le C_i$
OTHER CONSTRAINTS	$1 \cdots 1$ $1 \cdots 1$	$1 \cdots 1$ $1 \cdots 1$			$1 \ddots 1$		$1 \ddots 1$	$\ge K_i$ $\le K_n$

Figure 4.2: Schematic Picture of the Matrix, First Period

Labor activities. Labor supplies were assumed to be provided by the family or hired from the market at the going rate. The price of family labor used on the farm was endogenously estimated by the model. The price of family labor sold was given by the going market rate. The family was allowed to hire labor or to sell labor on a monthly basis, but the model's specifications required that all family labor was used first before hiring labor from the outside.

Storage activities. Storage was allowed for non-perishable crops such as rice, beans, corn and pigeon peas. The quantity storaged in one period was transferred to the next period via transfer rows and was available for consumption, sale or restorage in the next period. During the final period of the planning horizon, all production and inventory from the last period had to be sold or consumed. Eighteen storage activities were included in the basic model.

Financial activities. Financial activities allowed for borrowing from the Agriculture Development Bank or from private lenders at the going market interest rate, which was estimated at 12 percent per year. Also, capital could have been transferred from one period to the next via transfer vector columns.

Constraint Sets.

The constraint sets represented the land, labor and capital available or which could have been made available for production. In addition, restraints were included that could have been imposed by market conditions, government programs, farm management considerations, balance equations, recommended dietary allowance and dietary preferences.

Land constraints. This was defined as the maximum availability of land for production purposes. Two sub-sets of this type of constraint were used, one defining the monthly availability of type A land and one defining the land availability of type B land for each production period. The constraints are stated as

$$\sum_{i=1}^{22} lit \leq Lat \quad (4.3.1)$$

$$\sum_{i=1}^{13} lit \leq Lbt \quad (4.3.2)$$

where li = a vector of crop activities (tareas)
L = land availability (RHS)
t = production perios (t=1,2,3)
a = land type A at the farm and at the regional level
b = land type B at the farm and at the regional level

Labor constraints. These constraints defined the availability of family labor. The estimate was based on the average family size in the region. It was assumed that 260 days were devoted to crop production during the agricultural year, which ran from April to March. Each farm-household consisting of up to 6 members was assumed to provide 43.23 man-days of labor per month, families consisting of more than 6 members provided 54.15 man-days of labor per month. In addition, farm-households could hire labor from outside and sell labor away from the farm in case of deficit or surplus family labor conditions. Appendix F presents labor input coefficients. The labor constraints are defined as follows:

$$\sum_{i=1}^{35} aijLj + \Sigma Hj - \Sigma Si \leq Fj \qquad (4.4)$$

where aij = monthly requirements of labor i in man-days per tarea of crop j

Lj = tarea of crop j

Fj = family labor available on a monthly base (man-day)

Hj = hired labor on a monthly base (man-day)

si = sale of family labor off the farm on a monthly base (man-day)

Financial constraints. Capital availability has been related to farm size. Taking the actual production cost into account, it was estimated that an average of RD$40.00 per tarea were needed for production. It was assumed that the Agriculture Development Bank would provide 70 percent of the total production cost, and that the average farmer would provide the remaining 30 percent, a normal practice in the region. The average production cost then was multiplied by the number of tareas available on each representative farm, as well as by the number of tareas available at the regional level.

It was assumed also that income from the crops sold in one period would be available only to finance the crop production of the subsequent period. In this way the amount of capital borrowed was kept at a minimum, keeping the interest to be paid on loans by the farmers at the lowest possible level. The amount of capital borrowed at the beginning of the first planning period had to be repaid at the end of the planning horizon and any excess of capital was transferred to an account of capital inventory.

The equation used to represent the financial constraints is as follows:

(4.5)

$$- c - (1 - r)b + b + \Sigma\, vili - \Sigma\, ls + \Sigma\, lh + ct + \Sigma\, eifj = 0$$

where c = cash assets (pesos)
b = borrowed cash (pesos)
Vi = variable production cost (pesos)
li = crop activity level (tarea)
Ls = labor sale (pesos per man-day)
Lh = labor hired (pesos per man-day)
ct = capital transfer from one period to the next period
ei = retail food price paid by farmers (pesos per pound)
fj = food purchase vector (pound)

Balance equation. The balance equation distributed total output among family consumption, sales on the market and storage for future disposal. This assumed that the amount distributed could not excede the amount produced plus the inventory at the beginning of the period. This was specified as follows:

$$(4.6) \quad - Yjli - Ii + Si + C + Sf \leq 0$$

where Yj = yield of crop j (quintal)
li = crop activity level (tarea)
Ii = inventory at the beginning of the period
Si = sale vector (quintal)
Ci = home consumption (quintal)
Sf = storage for future disposal (quintal)

Nutritional constraints. This set of constraints required that the family intake from food, either coming from the farm or purchased in the market, had to be equal to or greater than the recommended dietary allowance for the family in the countryside. The basic model included eleven nutrients which had to be obtained from the 29 products. These basic nutrient requirments were calories, protein, fat, carbohydrates, calcium, iron, vitamine A, thiamine, niacine, riboflamine, vitamin C and a certain combination of animal and vegetable protein. These constraints were specified as

Table 4.4: Level of Constraints for the Individual Farmplan, Azua Plain, Dominican Republic, 1984.

Resource or constraint	Unit	Type of constraint	Resource level(*) (bi)		
			farm1	farm2	farm3
Land type A					
1 Landa1	tarea	L	18	42	88
2 Landa2	tarea	L	18	42	88
3 Landa3	tarea	L	18	42	88
4 Landa4	tarea	L	18	42	88
5 Landa5	tarea	L	18	42	88
6 Landa6	tarea	L	18	42	88
7 Landa7	tarea	L	18	42	88
8 Landa8	tarea	L	18	42	88
9 Landa9	tarea	L	18	42	88
10 Landa10	tarea	L	18	42	88
11 Landa11	tarea	L	18	42	88
12 Landa12	tarea	L	18	42	88
Land type B					
1 Landb1	tarea	L	7	18	37
2 Landb2	tarea	L	7	18	37
3 Landb3	tarea	L	7	18	37
4 Landb4	tarea	L	7	18	37
5 Landb5	tarea	L	7	18	37
6 Landb6	tarea	L	7	18	37
7 Landb7	tarea	L	7	18	37
8 Landb8	tarea	L	7	18	37
9 Landb9	tarea	L	7	18	37
10 Landb10	tarea	L	7	18	37
11 Landb11	tarea	L	7	18	37
12 Landb12	tarea	L	7	18	37
Labor					
1 Aprilab	man-day	L	43.23	54.15	54.15
2 Maylab	man-day	L	43.23	54.15	54.15
3 Junlab	man-day	L	43.23	54.15	54.15
4 Jullab	man-day	L	43.23	54.15	54.15
5 Auglab	man-day	L	43.23	54.15	54.15
6 Seplab	man-day	L	43.23	54.15	54.15
7 Octlab	man-day	L	43.23	54.15	54.15
8 Novlab	man-day	L	43.23	54.15	54.15
9 Declab	man-day	L	43.23	54.15	54.15
10 Janlab	man-day	L	43.23	54.15	54.15
11 Feblab	man-day	L	43.23	54.15	54.15
12 Marlab	man-day	L	43.23	54.15	54.15

Table 4.4 continued

Resource or constraint	Unit	Type of constraint	Resource level(*) (bi) farm1	farm2	farm3
Capital					
1 Cap. borrowed	pesos	L	700.	1680.	3500.
2 Finbal1	pesos	L			
3 Finbal2	pesos	L			
4 Finbal3	pesos	L			
5 Capinv	pesos	L	300.	700.	1500.
Balance row					
1 Dcorn	quintal	L			
2 Dsorg	quintal	L			
3 Drbea	quintal	L			
4 Dbbea	quintal	L			
5 Dgand	quintal	L			
6 Dplan	thousand	L			
7 Dyuc	quintal	L			
8 Dpep	quintal	L			
9 Dokr	quintal	L			
10 Dmel	hundred	L			
11 Dpea	quintal	L			
Nutrient constraints					
1 Cal	cal	G		1,440,000.0	
2 Prote	gram	G		33,060.0	
3 Fat	gram	G		40,800.0	
4 Carby	gram	G		259,500.0	
5 Calci	mgram	G		355,260.0	
6 Iron	mgram	G		11,700.0	
7 Vita	mcgram	G		654,288.0	
8 Thia	mgram	G		744.0	
9 Ribo	mgram	G		666.0	
10 Niac	mgram	G		7.362.0	
11 Vitc	mgram	G		113,052.0	
12 Anpro	gram	G		12,600.0	
13 Vegpro	gram	G		20,484.0	
14 Rbbal	lbs	G			
15 Robal	lbs	G			
16 Cmilk	liter	G			

(*) The entries in blank represent 0.

$$(4.7)\quad \sum_{j=1}^{29} aijQj + \sum_{j=1}^{14} aijFj \geq RDA$$

where aij = amount of nutrient i in each pound of product j
Qj = food purchase vector (pounds)
Fj = auto-consumption food vector (quintal)
RDA = recommended dietary allowance

Table 4.4 shows the level of constraints for the individual farm for the basic period.

Regional Approach.

The Azua plain has a total area of approximately 758,430 tareas or 47,700 ha. The newly irrigated area that has already been studied, mapped and classified according to its potential productive capacity, amounts to 457,542 tareas or 28,779 ha (SEA, 1981c).

Of the total land studied, 78 percent (356,926 tareas) was classified as crop land, of which 256,987 tareas (72 percent) was classified as type A land and 99,938 tareas (28 percent) as type B land. These figures were used as the land constraints for the regional model in a similar fashion as for the individual farm model. Most of this newly irrigated land will be used for a land reform program of family-farms averaging approximately 80 tareas. It was assumed that 4461 family-farms might be established in the region (IAD, 1977). Based on this, the field survey and other government information, aggregation for the DLP model was made possible at the regional level.

The activity sets presented for the individual farm models were generalized for the regional model. The models presented for the individual farms, equations (4.1) through (4.7), were adjusted to meet regional conditions. The interaction of the activities and constraints was specified using a structure similar to the individual farm models, but containing 435 columns and 164 rows. The aggregation of family labor for the region was based on 260 working days per agricultural year, which is the equivalent of 22 monthly man-days. In addition, it was assumed that the family provides 2 1/2 man-days of labor per day, resulting in 54.15 for each family-farm per month or 245,355 man-days of labor per year for all 4461 family-farms of the region. It was considered possible to sell or to hire labor on a monthly basis at the price of RD$4.00 per day.

Capital availability was estimated to be RD$14,277,040.0 for the region, farmers' investments amounting to 30 percent (RD$4,238,122.0) and loans from the Agricultural Bank making up the remaining 70 percent (RD$9,993,928.0). The above calculations were based on an average production cost in the region of RD$40.0 per tarea. In addition, a 12 percent interest rate per year was charged for the loans.

Nutritional constraints for the regional model were based on the recommended dietary allowance for the country (ONAPLAN, 1980). Table 4.5 presents the quarterly nutritional requirements. Consumption requirements were specified as in the individual farm model, based on a four month period. In addition to the constraints discussed above, balance and distribution rows, as well as marketing allotment rows, were included. Table 4.6 presents the constraints for the regional DLP model. Appendix F presents model coefficients at the regional level.

Table 4.5: Nutrient Constraints for the Individual Farm Household and for the Region, Azua Plain, Dominican Republic, 1983.

Nutrients	Unit	Month/ household	Quarter/ household	Quarter/ region
1 Calcium	kcal	360,000	1,440,000	6,423,840,000
2 Protein	gram	8.265	33,060	147,480,660
3 Fat	gram	10,200	40,800	182,008,880
4 Carbohydrates	gram	64,875	259,500	1,157,629,500
5 Calcium	mgram	88,815	355,260	1,584,814,800
6 Iron	mgram	2,925	11,700	52,193,700
7 Vitamin	mcgram	163,572	654,288	2,918,778,700
8 Thiamin	mgram	186	744	3,318,984
9 Riboflavin	mgram	166.5	666	2,971,026
10 Niacin	mgram	1,840.5	7,362	32,841,882
11 Vitamin C	mgram	28,263	113,052	504,324,970
12 Animal protein	gram	3,150	12,600	56,208.600
13 Vegetable protein	gram	5.121	20,484	91,399,124

Source: calculated from data presented by ONAPLAN, Sugerencias de Pautas Basicos para una Politica Nacional de Alimentacion y Nutricion, 1980, p.23.

Table 4.6: Level of Constraints in the Regional Farmland Dynamic Linear Programming Model of the Azua Plain,. Dominican Republic, 1983.

Resource or constraint	Unit	Type of constraint	Resource level (bi)
Land type A			
1 Landa1	tarea	L	256,987.0
2 Landa2	tarea	L	256,987.0
3 Landa3	tarea	L	256,987.0
4 Landa4	tarea	L	256,987.0
5 Landa5	tarea	L	256,987.0
6 Landa6	tarea	L	256,987.0
7 Landa7	tarea	L	256,987.0
8 Landa8	tarea	L	256,987.0
9 Landa9	tarea	L	256,987.0
10 Landa10	tarea	L	256,987.0
11 Landa11	tarea	L	256,987.0
12 Landa12	tarea	L	256,987.0
Land type B			
1 Landb1	tarea	L	99,939.0
2 Landb2	tarea	L	99,939.0
3 Landb3	tarea	L	99,939.0
4 Landb4	tarea	L	99,939.0
5 Landb5	tarea	L	99,939.0
6 Landb6	tarea	L	99,939.0
7 Landb7	tarea	L	99,939.0
8 Landb8	tarea	L	99,939.0
9 Landb9	tarea	L	99,939.0
10 Landb10	tarea	L	99,939.0
11 Landb11	tarea	L	99,939.0
12 Landb12	tarea	L	99,939.0
Labor			
1 Aprilab	man-day	L	245,355.0
2 Maylab	man-day	L	245,355.0
3 Junlab	man-day	L	245,355.0
4 Jullab	man-day	L	245,355.0
5 Auglab	man-day	L	245,355.0
6 Seplab	man-day	L	245,355.0
7 Octlab	man-day	L	245,355.0
8 Novlab	man-day	L	245,355.0
9 Declab	man-day	L	245,355.0
10 Janlab	man-day	L	245,355.0
11 Feblab	man-day	L	245,355.0
12 Marlab	man-day	L	245,355.0

Table 4.6 continued

Resource or Constraint	Unit	Type of Constraint	Resource level (bi)
Capital			
1 Capbor	pesos	L	9,993,928.0
2 Finbal1	pesos	L	
3 Finbal2	pesos	L	
4 Finbal3	pesos	L	
5 Capinv	pesos	L	4.283,112.0
Balance row			
1 Dcorn	quintal	L	
2 Dsorg	quintal	L	
3 Drbea	quintal	L	
4 Dbbea	quintal	L	
5 Dgand	quintal	L	
6 Dplan	thousand	L	
7 Dyuc	quintal	L	
8 Dpep	quintal	L	
9 Dokr	quintal	L	
10 Dmel	hundred	L	
11 Dpea	quintal	L	
Nutrient constraints			
1 Cal	calories	G	6,423,840,000.0
2 Prote	gram	G	147,480,660.0
3 Fat	gram	G	182,008,880.0
4 Carby	gram	G	1,157,629,500.0
5 Calci	mgram	G	1,584,814,800.0
6 Iron	mgram	G	52,193,700.0
7 Vita	mcgram	G	2,918,778,700.0
8 Thia	mgram	G	3,318,984.0
9 Ribo	mgram	G	2,971,026.0
10 Niac	mgram	G	32,841,882.0
11 Vitc	mgram	G	50,432,497.0
12 Anpro	gram	G	56,208,600.0
13 Vegpro	gram	G	91,399,124.0
14 Rbbal	lbs	G	
15 Robal	lbs	G	
16 Cmilk	liter	G	

*) The entries in blank represent 0.

CHAPTER V
EMPIRICAL RESULTS

The data developed in the preceding chapters were used in the DLP models to optimize net revenue and total output of crop production. The optimization was subject to land, labor, capital and nutritional requirement constraints for short-cycle cropping over a three period agricultural planning horizon. This chapter presents the analysis and results. Both the representative individual farm-household models and the regional models are discussed.

Optimal activity levels cover five categories: field crops, sales, home consumption, storage and food purchase. Two types of objective functions (net revenue and total output) are used to evaluate each one of the DLP models; four types of results are used to obtain insights into the capability and limitations of each one of the DLP models. These four types of results are the basis for the following procedures of analysis: a) the primal solution, which determines the array of different activity levels necessary for optimization of net revenue and total output; b) the dual solution, which determines the opportunity cost (shadow prices) of resources and requirements within the structure of the DLP model; c) range analysis, which provides an estimate of the range over which a shadow price is relevant; and d) parametric programming, which estimates the effect of either vector row or vector column changes upon the optimal plan.

Because of the comprehensive nature of the DLP models, which attempt to capture the most relevant aspects of the farm-households individually and of the region as a whole, results are complex and massive. Only the most relevant information for farmers and policy-makers is presented. Interpretation is confined to those farm-households of greatest potential productivity situated in the newly irrigated area.

Optimal Land Use and Resource Allocation on Individual Farms

The DLP model described in chapter IV has been solved under net revenue and total output maximization objectives for three representative farm-households of small farmers in the Azua plain. The farm sizes represented are 25, 60 and 125 tareas. The cropping plan consists of three recursive periods to covering the 12-month agricultural year.

Results for the 25 tareas farm-household models

The objectives of the models are to maximize net revenue and total output of short-cycle crops over the three period planning horizon. Net revenue is the return to land, labor and capital above all production and nutrient expenses. Returns are an accumulation of liquid capital assets. Total output is at the market value above all production expenses and includes the accumulation of liquid capital assets at the end of the planning horizon.

Tables 5.1 through 5.6 present the results of optimal farmland use and other resource allocation plans for the 25 tareas farm-households under the net revenue and total output maximization objectives. The maximum revenue obtained is estimated at RD$4,336.21. This is accomplished by planting the crop mix and by consuming the combination of foods presented in table 5.1.

During the April-July period the farm-household optimal plan consists of growing 4.82 tareas of rice on land type A with technology 3, 13.18 tareas of black beans on land type A with technology 3, 0.26 tareas of pigeon peas on land type B with technology 3, 6.35 tareas of plantain on land type B with technology 3, and 0.39 tareas of peanuts on land B with technology 1 (figure 5.1). Part of the output is used for home consumption and the remainder is marketed.

Nutritional requirements for the household are satisfied by combining consumption of household food crops with the food purchases (table 5.1). For instance, 0.50 quintal of pigeon peas produced on the farm is used for home consumption during the first period. In the same period, 250 pounds of rice are purchased, as well as the other foods presented under the heading "food purchased" in table 5.1.

The most profitable crop activity under the net revenue maximization objective is black beans; it takes up 13.18 tareas. Black beans are prescribed at such a high level (73 percent of land type A) because of the short production cycle, low production costs, relatively good yield and favorable prices. Also, black beans, when used for home consumption, are a good source for calories, protein and iron, and they are a cash crop with a stable market price.

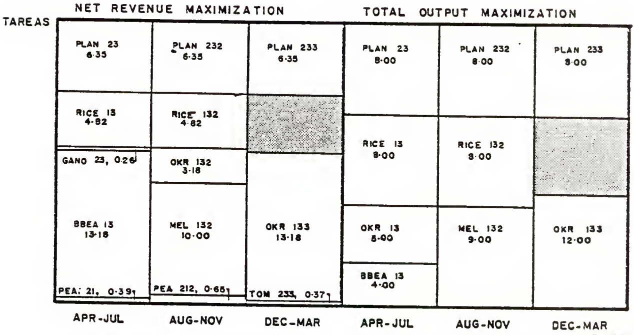

FIGURE 5·1: OPTIMAL 25 TAREAS FARM LAND USE PATTERN UNDER NET REVENUE AND TOTAL OUTPUT MAXIMIZATION

Table 5.1: Optimal 25 Tareas Farm-Household Plan for Production and Consumption under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984

		Net Revenue			Total Output	
Activity	Unit	Activity level	Input cost	Food cost	Activity level	Input cost
Field crop						
1st period, Apr-Jul						
Rice13	tarea	4.82	351.38		8.00	580.80
Bbea13	tarea	13.18	241.85		4.00	88.45
Gand23	tarea	0.26	5.33		-	-
Plan33	tarea	6.35	46.67		8.00	51.45
Okr13	tarea	-	-		5.00	301.68
Pea21	tarea	0.39	7.09		-	-
2nd period, Aug-Nov						
Rice132	tarea	4.82	350.32		8.00	581.44
Plan232	tarea	6.35	23.37		8.00	25.76
Okr132	tarea	3.18	185.52		-	-
Mel132	tarea	10.00	916.00		10.00	916.00
Pea212	tarea	0.65	11.82		-	-
3rd period, Dec-Mar						
Rbea223	tarea	0.26	5.89		-	-
Plan233	tarea	6.35	23.37		8.00	25.76
Okr133	tarea	13.18	768.92		10.00	583.40
Tom233	tarea	0.37	22.51		-	-
Home consumption						
1st period, Apr-Jul						
Cgand	quintal	0.50				
Cpea	quintal	0.58				
2nd period, Aug-Nov						
Cpea2	quintal	0.97				
3rd period, Dec-Mar						
Ctom3	quintal	16.68				
Food Purchase						
1st period, Apr-Jul						
Frice	lbs	240.00	0.28	67.20		
Fpast	lbs	50.00	0.28	14.00		
Fcorn	lbs	150.00	0.14	21.00		
Fbean	lbs	80.00	0.38	30.04		
Fplan	lbs	1449.00	0.10	144.09		
Fbeef	lbs	0.95	0.80	0.73		
Fchic	lbs	75.00	0.65	56.25		
Fsard	lbs	58.27	1.10	64.11		
Fmilk	bottle	40.82	0.66	26.94		

Table 5.1 continued

		Net Revenue		
Activity level	Unit	Activity level	Input cost	Food cost
Food purchase				
1st period, Apr-Jul				
Fdmilk	lbs	19.17	2.58	49.46
Foil	lbs	24.00	1.20	28.80
Fsalt	lbs	10.00	0.10	1.00
2nd period, Aug-Nov				
Frice2	lbs	240.00	0.28	67.02
Fpast2	lbs	50.00	0.28	14.00
Fcorn2	lbs	150.00	0.14	21.00
Fyuc2	lbs	628.00	0.08	50.24
Fbean2	lbs	80.00	0.38	30.40
Fplan2	lbs	400.00	0.10	40.00
Fchic2	lbs	75.00	0.65	47.75
Fcodf2	lbs	48.58	1.02	49.55
Fmilk2	liter	60.00	0.66	39.60
Foil2	lbs	24.00	1.20	28.80
3rd period, Dec-Mar				
Frice3	lbs	240.00	0.28	67.72
Fpast3	lbs	50.00	0.28	14.00
Fcorn3	lbs	150.00	0.14	21.00
Fbean3	lbs	80.00	0.38	30.40
Fplan3	lbs	400.00	0.10	40.00
Fchic3	lbs	75.00	0.65	48.75
Farren3	lbs	61.71	0.87	53.69
Fsard3	lbs	39.57	1.10	43.53
Fmilk3	liter	60.00	0.66	39.60
Foil3	lbs	24.00	1.20	28.80
Fsalt3	lbs	10.00	0.10	1.00

When the farmer aims to maximize total output, the objective function takes a value of RD$6,141.61. Field crop activities selected during the first period are: 8 tareas of rice on land type A with technology 3, 4 tareas of black beans on land type A with technology 3, 8 tareas of plantain on land type B with technology 3, and 5 tareas of okra on land type A with technology 3 (total output, table 5.1). It should be noted, however, that the crop mix changes under different objectives. Under the net revenue objective, the crop mix is more diversified and reflects that attention is paid both to market prices and to family consumption needs. Under total output maximization, production tends to be more commercially oriented as family food supply is not considered; crops such as okra and melon are brought up to the maximum market allotment.

The DLP model also was solved under the objective function of net revenue maximization not allowing for family labor sale off the farm (table 5.2). Because labor can only be devoted to on-farm crop production, crop mix becomes more diversified. Crop activities increase from 12 to 16 for the annual planning horizon, while food purchases become more concentrated, decreasing from 12 to 8 different items being bought during the first planning period.

Output distribution for the optimal plan is presented in tables 5.3 and 5.4, which gives information on optimal field crop activities and on output distribution among sale, home consumption and storage for future disposal. For instance, rice produced during the first planning period (39.40 quintal) is distributed as follows: 19.22 quintal are sold at the market and 20.18 quintal are stored for future disposal.

Table 5.2: Optimum 25 Tareas (No Labor Sold) Farm-Household Plan for Production and Consumption under the Net Revenue Maximizing Objective, Azua, Dominican Republic, 1984.

		Net Revenue		
Activity	Unit	Activity level	Input cost	Food cost
Field crops				
1st period, Apr-Jul				
Rice13	tarea	1.70	123.42	
Bbea13	tarea	15.10	277.09	
Gand11	tarea	0.19	2.58	
Gand23	tarea	0.71	14.56	
Plan23	tarea	5.69	83.70	
Oni13	tarea	1.01	72.59	
Pea21	tarea	0.60	10.91	
2nd period, Aug-Nov				
Rice132	tarea	1.70	123.56	
Bbea232	tarea	0.64	11.74	
Plan232	tarea	5.69	83.70	
Pep232	tarea	0.02	0.86	
Okr132	tarea	6.10	355.87	
Mel132	tarea	10.00	910.60	
Pea212	tarea	0.65	11.82	
3rd period, Dec-Mar				
Rbea223	tarea	0.92	20.56	
Plan233	tarea	5.69	83.70	
Okr133	tarea	16.29	950.36	
Tom233	tarea	0.37	22.41	
Home consumption				
1st period, Apr-Jul				
Cgand	quintal	2.71		
Cpea	quintal	0.90		
2nd period, Aug-Nov				
Cpea2	quintal	0.97		
3rd period, Dec-Mar				
Ctom	quintal	16.78		

Table 5.2 continued

Activity	Unit	Net Revenue		
		Activity level	Input cost	Food cost
Food purchase				
1st period, Apr-Jul				
Fcorn	lbs	150.00	0.14	21.00
Fbean	lbs	80.00	0.38	30.04
Fplan	lbs	1543.00	0.10	154.30
Fchic	lbs	75.00	0.65	48.75
Fcodf	lbs	48.59	1.02	49.56
Fmilk	bottle	60.00	0.66	39.60
Foil	lbs	24.00	1.20	28.80
Fsalt	lbs	10.00	0.10	1.00
2nd period, Aug-Nov				
Frice2	lbs	240.00	0.28	67.20
Fpast2	lbs	50.00	0.28	14.00
Fcorn2	lbs	150.00	0.14	21.00
Fyuc2	lbs	628.71	0.08	50.30
Fbean2	lbs	80.00	0.38	30.04
Fplan2	lbs	400.00	0.10	40.00
Fchic2	lbs	75.00	0.65	48.75
Fcodf2	lbs	48.58	1.02	49.55
Fmilk2	bottle	60.00	0.66	39.06
Foil2	lbs	24.00	1.20	28.08
3rd period, Dec-Mar				
Frice3	lbs	240.00	0.28	67.02
Fpast3	lbs	50.00	0.28	14.00
Fcorn3	lbs	150.00	0.14	21.00
Fyuc3	lbs	101.57	0.08	8.13
Fbean3	lbs	80.00	0.38	30.05
Fplan3	lbs	400.00	0.10	40.00
Fchic3	lbs	75.00	0.65	48.75
Farren3	lbs	75.57	0.87	65.75
Fsard3	lbs	31.00	1.10	34.10
Fmilk3	bottle	60.00	0.66	39.60
Foil3	lbs	24.00	1.20	28.80
Fsalt3	lbs	10.00	0.10	1.00

Table 5.3: Optimal Field Crop Activities and Output Distribution under the Net Revenue Maximization Objective for 25 Tareas Farm-Households, Azua, Dominican Republic, 1984.

Field crop	Unit	Activity level (tarea)	Total output	Sale	Home consumption	Storage
1st period, Apr-Jul						
Rice13	quintal	4.82	39.40	19.22	-	20.18
Bbea13	quintal	13.18	26.37	26.37	-	-
Gand23	quintal	0.26	0.78	-	0.50	0.28
Plan23	thousand	6.35	5.40	5.40	-	-
Pea21	quintal	0.39	0.58	-	0.58	-
2nd period, Aug-Nov						
Rice132	quintal	4.82	39.75	39.75	-	-
Plan232	thousand	6.35	5.40	5.40	-	-
Okr132	quintal	3.18	38.19	38.19	-	-
Mel13	hundred	10.00	450.00	450.00	-	-
Pea212	quintal	0.65	0.97	-	0.97	-
3rd period, Dec-Mar						
Rbea223	quintal	0.26	0.39	0.39	-	-
Plan233	thousand	6.35	5.40	5.40	-	-
Okr133	quintal	13.18	158.16	158.19	-	-
Tom233	quintal	0.37	16.68	16.68	-	-

Tables 5.5 and 5.6 provide information on the resources used and non-used in the optimal production process. The 25 tareas of farmland are fully utilized under both objective functions, except for 4.82 tareas during the months of February and March under the net revenue maximization objective, and 8.00 tareas during the same months under the total output maximization objective. This is due to the carrying over of 4.28 and 8.00 tareas of rice from one period to the first two months of the next period, leaving the remaining two months of the third period unused, as no crops are available that can be grown in such a short period.

Table 5.4: Optimal Field Crop Activities and Output Distribution under the Net Revenue Maximization Objective for 25 Tareas Farm-Households (No Labor Sold) Azua,. Dominican Republic, 1984.

Field crop	Unit	Activity level (tarea)	Total output	Sale	Home consumption	Storage
1st period, Apr-Jul						
Rice13	quintal	1.70	13.93	13.93	-	-
Bbea13	quintal	15.10	30.18	30.18	-	-
Gand11	quintal	0.19	0.57	-	0.57	-
Gand23	quintal	0.71	2.14	-	2.14	-
Plan23	thousand	5.69	4.84	4.84	-	-
Oni13	quintal	1.01	13.37	13.37	-	-
Pea21	quintal	0.60	0.90	-	0.90	-
2nd period, Aug-Nov						
Rice132	quintal	1.70	13.93	13.93	-	-
Bbea232	quintal	0.64	1.28	1.28	-	-
Plan232	thousand	5.69	4.84	4.84	-	-
Pep232	quintal	0.02	0.22	0.22	-	-
Okr132	quintal	6.10	73.23	73.23	-	-
Mel132	hundred	10.00	450.00	450.00	-	-
Pea212	quintal	0.65	0.97	-	0.97	-
3rd period, Dec-Mar						
Rbea223	quintal	0.92	1.38	1.38	-	-
Plan233	thousand	5.65	4.48	4.48	-	-
Okr133	quintal	16.29	195.56	195.56	-	-
Tom233	quintal	0.37	16.78	-	16.78	-

All family labor is utilized, because when labor is not needed on the farm it is sold off the farm under both objective functions. Also, some outside labor is hired during the critical periods such as the harvest. In the case that no allowance is made for the sale of labor, a large proportion of family labor becomes idle during the months of May, June, August, September, October, January and February (table 5.6).

Table 5.5: Comparison of Resources Used, Not-Used and Shadow Prices for the Optimal 25 tareas Farm-Household Plan,.under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic,.1984.

Resource	Unit	Net Revenue			Total Output		
		Resources		Shadow	Resources		Shadow
		used	not-used	price	used	not-used	price
1st period, Apr-Jul							
Landa1	tarea	18.00	-	-	18.00	-	-
Landa2	tarea	18.00	-	-	18.00	-	-
Landa3	tarea	18.00	-	-	18.00	-	-
Landa4	tarea	18.00	-	10.94	18.00	-	14.48
Landb1	tarea	7.00	-	15.81	7.00	-	11.48
Landb2	tarea	7.00	-	-	7.00	-	-
Landb3	tarea	7.00	-	-	7.00	-	-
Landb4	tarea	7.00	-	-	7.00	-	-
Aprilab	man-day	43.23	-	6.46	43.23	-	6.07
Maylab	man-day	43.23	-	6.46	43.23	-	6.07
Junlab	man-day	43.23	-	6.46	43.23	-	6.07
Jullab	man-day	43.23	-	6.46	43.23	-	6.07
Finbal	pesos	300.00	-	0.61	300.00	-	0.52
Capbor	pesos	700.00	-	0.49	700.00	-	0.40
2nd period, Aug-Nov							
Landa5	tarea	18.00	-	0.31	18.00	-	17.60
Landa6	tarea	18.00	-	9.60	18.00	-	40.80
Landa7	tarea	18.00	-	-	18.00	-	0.82
Landa8	tarea	18.00	-	12.14	18.00	-	-
Landb5	tarea	7.00	-	9.22	7.00	-	-
Landb6	tarea	7.00	-	39.33	7.00	-	-
Landb7	tarea	7.00	-	-	7.00	-	-
Landb8	tarea	6.35	-	-	7.00	-	33.05
Auglab	man-day	43.20	-	4.00	43.20	-	4.00
Seplab	man-day	43.20	-	4.00	43.20	-	4.00
Octlab	man-day	43.20	-	4.00	43.20	-	4.00
Novlab	man-day	43.20	-	4.00	43.20	-	4.00
3rd period, Dec-Mar							
Landa9	tarea	18.00	-	55.14	18.00	-	-
Landa10	tarea	18.00	-	-	18.00	-	55.14
Landa11	tarea	13.18	4.82	-	10.00	8.00	-
Landa12	tarea	13.18	4.82	-	10.00	8.00	-
Landb9	tarea	7.00	-	-	7.00	-	-
Landb10	tarea	7.00	-	17.20	7.00	-	-
Landb11	tarea	7.00	-	-	7.00	-	-
Landb12	tarea	7.00	-	-	7.00	-	-
Declab	man-day	43.20	-	4.00	43.20	-	4.00
Janlab	man-day	43.20	-	4.00	43.20	-	4.00
Feblab	man-day	43.20	-	4.00	43.20	-	4.00
Marlab	man-day	43.20	-	4.00	43.20	-	4.00

Table 5.6: Resources Used, Non-Used and Shadow Prices for the 25 Tareas (no Labor Sold) Farm-Household Plan the under Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Resource	Unit	Resources		Shadow
		used	non-used	price
1st period, Apr-Jul				
Landa1	tarea	18.00	-	-
Landa2	tarea	18.00	-	-
Landa3	tarea	18.00	-	43.63
Landa4	tarea	18.00	-	-
Landb1	tarea	7.00	-	49.33
Landb2	tarea	7.00	-	-
Landb3	tarea	7.00	-	-
Landb4	tarea	7.00	-	-
Aprlab	man-day	43.23	-	0.22
Maylab	man-day	22.17	21.06	-
Junlab	man-day	15.37	27.86	-
Jullab	man-day	42.61	0.95	-
Finbal	pesos	300.00	-	3.01
Capinv	pesos	700.00	-	2.89
2nd period, Aug-Nov				
Landa5	tarea	18.00	-	21.82
Landa6	tarea	18.00	-	11.57
Landa7	tarea	18.00	-	-
Landa8	tarea	17.81	0.19	-
Landb5	tarea	7.00	-	30.03
Landb6	tarea	7.00	-	-
Landb7	tarea	7.00	-	-
Landb8	tarea	6.35	0.65	-
Auglab	man-day	25.31	17.89	-
Seplab	man-day	20.75	22.45	-
Octlab	man-day	30.04	13.16	-
Novlab	man-day	43.20	-	6.72
3rd period, Dec-Mar				
Landa9	tarea	18.00	-	69.74
Landa10	tarea	18.00	-	-
Landa11	tarea	16.30	1.70	-
Landa12	tarea	16.30	1.70	-
Landb9	tarea	7.00	-	5.03
Landb10	tarea	7.00	-	29.38
Landb11	tarea	6.98	0.02	-
Landb12	tarea	6.98	0.02	-
Declab	man-day	33.57	9.63	-
Janlab	man-day	26.63	16.57	-
Feblab	man-day	22.46	20.74	-
Marlab	man-day	43.20	-	4.00

The dual solution is presented also in table 5.5. It is a key element because it indicates the marginal value of products, or shadow price, associated with the limiting resources or constraints. Because the constraints in land, labor and capital are "less than" requirements, these indicate how much will be added to net revenue or total output if one or more units of the limiting resource could be made available.

A shadow price of RD$15.81 per tarea of land type B during the first month (landb1) of the first production period indicates that this resource is a limiting factor, and additional units of this land could be used to produce plantain. Thus, if landb1 were increased by one unit, net revenue would increase by RD$15.81. A similar interpretation is valid for labor during April when any additional man-day of labor would increase net revenue by RD$6.46; as far as capital borrowing is concerned, net revenue would increase by RD$0.49 for each additional pesos borrowed by the farm-household. Conversely, resources non-used or in excess in the production process are priced at zero because they would add nothing to net revenue if more of that resource would be used. Marginal value products of resources when labor sale was not permitted is presented in table 5.6. The interpretation of the results is as in table 5.5.

The preceding sections raise the questions of stability of the optimal solution and determination of how much change would be required in individual coefficients of the objective functions or in individual values of the resources available before a change in basis occurs. In other words, attention will now be turned to the effect of individual changes in input output coefficients at the margin, with other factors and coefficients held constant. It was argued in the preceding section that the shadow price for disposal activities indicates the marginal contribution to net revenue or total output of the last unit of resources. Shadow prices do not specify how many units of a resource could be added without lowering its marginal contribution. Table 5.7 shows the marginal value products or shadow prices of the limiting resources for the 25 tareas farm-households and the range over which the shadow prices are relevant.

In August, all available land type A (18.0 tareas) is used, becoming an effective constraint with a shadow price of RD$9.60 per tarea. The column headed "range of shadow price" presents the range over which the shadow price of RD$9.60 per tarea of land type A is relevant during August. Each tarea of land type A reduced from 18.00 down to 17.47 would reduce the value of net revenue by RD$9.60 . Each tarea of land added beyond 18.00 to 22.82 would add RD$9.60 to the value of the program.

Table 5.7: Marginal Value Productivities of Scarce Resources and Range under the Net Revenue Maximization Objective for the 25 tareas Farm-Household Plan, Azua, Dominican Republic, 1984.

Resource	Unit	Resource level	Shadow price	Range of Shadow Price lower	Range of Shadow Price upper
Landa4	tarea	18.00	10.90	16.80	18.00
Landb1	tarea	7.00	15.81	6.56	7.00
Aprilab	man-day	43.23	6.46	42.69	54.20
Maylab	man-day	43.24	6.46	19.68	54.20
Junlab	man-day	43.23	6.46	16.51	54.20
Jullab	man-day	43.20	6.46	43.66	54.17
Finbal	pesos	300.00	0.61	110.20	343.88
Capbor	pesos	700.00	0.49	510.20	743.88
Landa5	tarea	18.00	9.60	17.47	22.82
Landa6	tarea	18.00	29.48	18.00	18.00
Landa8	tarea	18.00	12.14	17.84	18.00
Landb5	tarea	7.00	9.22	6.98	7.00
Landb6	tarea	7.00	39.33	7.00	7.00
Auglab	man-day	43.20	4.00	17.81	168.14
Seplab	man-day	43.20	4.00	21.30	168.14
Octlab	man-day	43.20	4.00	30.17	168.14
Novlab	man-day	43.20	4.00	88.00	58.62
Landa9	tarea	18.00	55.14	14.70	18.00
Landb10	tarea	7.00	17.20	6.74	7.02
Declab	man-day	43.20	4.00	28.96	inf
Janlab	man-day	43.20	4.00	40.68	inf
Feblab	man-day	43.20	4.00	18.99	inf
Marlab	man-day	43.20	4.00	438.32	56.32

inf = infinite

Similarly, capital borrowing has a shadow price of RD$0.49 for each pesos borrowed. Thus, any reduction of each pesos borrowed from RD$700.00 to RD$500.00 would reduce the program by RD$0.49. Each pesos added from RD$700.00 to RD$743.88 would add RD$0.49 to the program.

The previous sections discussed real activities which enter the plan. Because the plan was optimal, diverging from it would cause a decrease in the value of the program.

Stability of the optimal solution will now be discussed using tables 5.8 and 5.9. The income penalties column of table 5.8 gives insight into the magnitude of the income penalties which are attached to the departure from the optimum on either the up or down side.

Rice (rice13) is in the solution at a level of 4.81 tareas. The income penalty column indicates that an income penalty of RD$8.00 arises for each tarea the activity is decreased below the optimum. This penalty applies until the acreage is decreased to 2.47 (activity range limit column). Below this the penalty presumably increases. If the land used for rice production is pushed beyond the optimum, the penalty is RD$5.19 per tarea. This penalty applies up to 4.82 tareas.

The column "activity range limit" indicates how much would be produced associated with the new coefficient in the objective function. It provides an estimate of the sensitivity of an activity to changes in the coefficients (varible cost prices) of the objective function.

For example, activity rice13 has a coefficient of 72.60 in the objective function (Cj value) which is the variable cost of producing one tarea of rice on land type A with technology 2. This coefficient (variable cost) can vary upward from 67.41 to 80.60 before changes in the level of rice13 would occur in the solution. At 67.41 the level of rice13 would drop to 2.47 tareas; at 80.60 it would go

Table 5.8: Stability of the Optimal 25 Tareas Farm-Household under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Input cost	Income Penalty		Activity Range Limit		Cost Range Limit	
				lower	upper	lower	upper	lower	upper
Field crops									
Rice13	tarea	4.81	72.60	8.00	5.19	2.47	4.82	67.41	80.40
Bbea13	tarea	13.18	18.35	0.56	10.85	13.18	13.18	7.50	18.91
Gand23	tarea	0.26	20.50	6.56	2.49	0.10	0.26	18.01	27.06
Plan23	tarea	6.35	14.71	9.22	7.25	6.34	6.40	7.46	23.93
Pea21	tarea	0.38	18.18	9.22	36.50	0.34	0.42	18.32	27.40
Rice132	tarea	4.28	72.68	8.00	2.29	2.47	4.82	70.39	80.68
Okr132	tarea	3.18	58.34	2.29	8.00	3.18	5.53	50.34	60.63
Mel132	tarea	10.00	91.60	45.46	inf	0.0	10.00	inf	137.06
Pea212	tarea	0.65	18.18	7.25	26.57	0.50	0.65	8.39	25.92
Rbea223	tarea	0.26	22.67	7.25	0.49	0.11	0.26	22.18	29.92
Okr133	tarea	13.18	58.34	2.29	8.00	13.18	15.53	50.34	60.63
Tom233	tarea	0.37	60.85	23.99	24.56	0.0	0.62	36.29	84.84
Food purchase									
Frice	lbs	240.00	0.28	20.52	0.63	239.32	251.55	0.35	20.80
Fpast	lbs	50.00	0.28	inf	0.42	50.00	91.90	0.13	inf
Fcorn	lbs	150.00	0.14	10.19	0.12	149.26	222.90	0.02	10.33
Fbean	lbs	50.00	0.38	16.47	1.88	79.90	83.85	1.50	16.85
Fplan	lbs	1449.05	0.10	0.02	0.01	1395.93	1449.05	0.09	0.12
Fbeef	lbs	0.95	0.80	0.48	0.42	-14.49	0.95	0.38	1.28
Fchic	lbs	75.00	0.65	inf	0.47	75.00	90.07	0.18	inf
Fsard	lbs	58.28	1.10	0.05	0.02	38.82	58.28	1.08	1.15
Fmilk	bottle	40.83	0.66	0.05	0.02	22.47	40.83	0.64	0.72
Fdmilk	lbs	19.17	2.58	0.02	0.06	19.17	37.53	2.52	2.60
Foil	lbs	24.00	1.20	inf	6.28	24.00	25.16	5.07	inf
Fsalt	lbs	10.00	0.10	0.32	inf	-3.99	10.00	inf	0.42
Frice2	lbs	240.00	0.28	inf	0.38	240.00	319.56	0.10	inf
Fpast2	lbs	50.00	0.28	inf	0.27	50.00	890.05	0.01	inf
Fcorn2	lbs	150.00	0.14	18.82	0.13	150.00	1011.83	0.01	18.96
Fyuc2	lbs	628.71	0.08	0.04	0.08	-5983.46	3728.95	0.0	0.12
Fbean2	lbs	80.00	0.38	32.44	1.14	71.07	106.52	0.76	32.82
Fplan2	lbs	340.00	0.10	inf	0.04	400.00	1271.62	0.06	inf
Fchic2	lbs	75.00	0.65	inf	0.20	75.00	207.59	0.45	inf
Fcodf2	lbs	48.59	1.02	0.17	1.01	42.58	265.64	0.01	1.19
Fmilk2	bottle	60.00	0.66	0.97	0.50	17.51	270.60	0.16	1.36
Foil2	lbs	24.00	1.20	inf	0.81	24.00	31.96	2.61	inf
Frice3	lbs	240.00	0.28	14.69	0.33	240.00	248.93	0.05	14.97
Fpast3	lbs	50.00	0.28	inf	0.16	50.00	63.93	0.12	inf

Table 5.8 continued

Activity	Unit	Activity level	Input cost	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Food purchase									
Fcorn3	lbs	150.00	0.14	inf	0.05	150.00	165.90	0.09	inf
Fbean3	lbs	80.00	0.38	inf	0.99	80.00	82.98	0.61	inf
Fplan3	lbs	340.00	0.10	inf	0.06	400.00	499.97	0.04	inf
Fchic3	lbs	75.00	0.65	inf	0.34	75.00	105.67	0.31	inf
Farren3	lbs	61.71	0.87	0.04	0.06	32.38	75.14	0.81	0.91
Fsard3	lbs	39.57	1.10	0.05	0.12	-43.26	72.95	0.98	0.73
Fmilk3	bottle	60.00	0.66	0.07	0.37	44.50	150.00	0.29	0.73
Foil3	lbs	24.00	1.20	inf	3.28	24.00	24.89	2.08	inf
Fsalt3	lbs	10.00	0.10	0.32	inf	-29.86	10.00	inf	0.42

inf = infinite

Table 5.9: Stability of the Optimal 25 Tareas (no Labor Sold) Farm Household Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Field crops									
Rice13	tarea	1.70	72.60	9.80	0.32	1.70	1.96	72.28	82.40
Bbea13	tarea	15.09	18.35	1.38	1.20	15.09	15.09	17.15	20.18
Gand11	tarea	0.19	13.60	1.60	2.10	0.19	0.19	11.50	15.20
Plan23	tarea	5.69	14.71	1.60	2.47	5.69	5.72	12.24	16.31
Oni13	tarea	1.01	71.87	0.33	22.24	0.76	2.19	49.63	27.20
Pea21	tarea	0.60	18.18	13.36	84.50	-0.11	1.47	66.32	31.54
Rice132	tarea	1.70	72.68	9.80	0.32	1.70	1.96	72.36	82.48
Bbea232	tarea	0.64	18.35	2.47	1.60	0.61	0.64	16.75	20.82
Pep232	tarea	0.02	43.00	5.03	29.38	0.0	0.51	13.62	48.03
Okr132	tarea	6.10	58.34	0.29	1.67	5.81	6.65	56.67	58.63
Mel132	tarea	10.00	91.60	2.86	inf	9.68	10.00	inf	94.46
Pea212	tarea	0.65	18.18	13.26	38.08	0.15	1.34	19.90	31.44
Rbea223	tarea	0.92	22.67	2.47	1.60	0.88	0.92	21.07	25.14
Okr133	tarea	16.30	58.34	0.32	4.84	16.04	16.30	53.48	58.66
Tom233	tarea	0.37	60.85	20.54	20.16	0.0	1.23	40.69	81.39

Table 5.9 continued

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Food purchase									
Frice	lbs	240.00	0.28	35.16	1.78	237.79	289.49	1.50	35.44
Fpast	lbs	50.00	0.28	inf	1.15	50.00	132.61	0.87	inf
Fcorn	lbs	150.00	0.14	13.07	0.33	144.64	445.21	0.19	13.21
Fbean	lbs	80.00	0.38	31.28	5.35	78.27	96.50	4.97	31.66
Fplan	lbs	1543.08	0.10	0.26	0.36	1271.62	1543.08	0.26	0.36
Fchic	lbs	75.00	0.65	inf	0.98	75.00	174.23	0.33	inf
Fcodf	lbs	48.59	1.02	0.69	3.95	17.12	74.50	2.93	1.71
Fmilk	bottle	60.00	0.66	1.16	1.65	29.06	112.15	0.99	1.82
Foil	lbs	24.00	1.20	inf	17.83	24.00	28.95	16.63	inf
Fsalt	lbs	10.00	0.10	0.33	inf	32.84	10.00	inf	0.43
Frice2	lbs	240.00	0.28	inf	0.77	240.00	356.04	0.49	inf
Fpast2	lbs	50.00	0.28	inf	0.49	50.00	232.10	0.21	inf
Fcorn2	lbs	150.00	0.14	20.14	0.23	150.00	586.65	0.09	20.28
Fyuc2	lbs	628.71	0.08	0.02	0.19	139.99	961.52	0.11	0.10
Fbean2	lbs	80.00	0.38	13.16	2.30	78.60	118.68	1.92	31.54
Fplan2	lbs	400.00	0.10	inf	0.03	400.00	1142.40	0.07	inf
Fchic2	lbs	75.00	0.65	inf	0.41	75.00	207.59	0.24	inf
Fcodf2	lbs	48.59	1.02	1.00	1.70	-26.25	104.07	0.68	2.02
Fmilk2	bottle	60.00	0.66	1.88	1.89	11.16	170.29	0.23	2.54
Foil2	lbs	24.00	1.20	inf	7.68	24.00	35.60	6.48	inf
Frice3	lbs	240.00	0.28	9.60	0.25	239.64	262.19	0.03	9.88
Fpast3	lbs	50.00	0.28	inf	0.11	50.00	84.60	0.17	inf
Fcorn3	lbs	150.00	0.14	inf	0.01	150.00	189.50	0.13	inf
Fyuc3	lbs	101.57	0.08	0.0	0.04	-127.82	445.58	0.04	0.08
Fbean3	lbs	80.00	0.38	inf	0.74	80.00	87.40	0.36	inf
Fplan3	lbs	400.00	0.10	inf	0.05	400.00	552.72	0.05	inf
Fchic3	lbs	75.00	0.65	inf	0.38	75.00	96.91	0.27	inf
Farren3	lbs	73.57	0.87	0.0	0.01	-7.82	95.08	0.86	0.88
Fsard3	lbs	31.81	1.10	0.02	0.09	17.72	43.30	1.01	1.12
Fmilk3	bottle	60.00	0.66	0.03	0.36	26.55	254.44	0.30	0.69
Foil3	lbs	24.00	1.20	inf	2.46	24.00	26.22	1.26	inf
Fsalt3	lbs	10.00	0.10	0.35	inf	-17.68	10.00	inf	0.45

to 4.82, which means that the solution is relatively stable. Interpretation of stability of other production activities follows the same pattern.

The solution for consumption activities or food purchase is presented in table 5.8. Beans have a coefficient of 0.38 in the objective function (Cj) which represents the cost of a pound of beans purchased in the market for family consumption. This cost (or price paid) by the farmer can vary from -16.85 up to 1.50 before changes in the level of bean consumption would occur.

Table 5.9 presents information to evaluate the stability of the solution when no labor is permitted to be sold. Interpretation of this table is the same as for table 5.8.

Table 5.10 presents information on prices and is used to analyze the stability of the optimal farm-household plan solution in terms of price changes. Plantain has a sale price of RD$50.00 per unit of one thousand. This is the figure entered into the objective function as a Cj coefficient. This coefficient can vary upwards from 38.39 to 58.80 before a change would occur in the level of plantain sale. In other words, whenever the price of any selected selling activity takes a value outside of the price range limits, the optimum farm-household plan will change. The usefulness of this information in terms of price policy is that this kind of analysis enables

Table 5.10: Price Range for the Optimal 25 Tareas Farm-Household Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Sale	Price Range Limit			
			(labor sold)		(no labor sold)	
		Price	upper	lower	upper	lower
Srice	quintal	26.00	26.00	25.97	26.04	24.80
Sbbea	quintal	35.00	40.42	35.00	35.60	34.08
Splan	thousand	50.00	58.80	38.39	52.90	48.11
Soni	quintal	15.00	-	-	16.68	14.97
Srice2	quintal	26.00	26.03	26.00	26.04	26.00
Splan2	thousand	50.00	58.53	39.15	52.90	48.11
Spep2	quintal	10.00	-	-	12.45	9.58
Soni2	quintal	15.00	-	-	18.97	6.18
Sokr2	quintal	12.00	12.67	11.81	12.14	11.98
Smel2	hundred	4.00	inf	3.16	inf	3.95
Srbea3	quintal	38.05	38.38	38.00	39.12	38.00
Splan3	thousand	50.00	58.53	39.15	52.90	48.11
Sokr3	quintal	12.00	12.67	11.81	12.41	11.97

inf = infinite

policy-makers to use price policy as a tool to encourage or discourage farmers to produce larger outputs or to increase or decrease the share of output marketed in the context of small farmers. Information about labor hired and sold is presented in appendix G.

Results for the 60 tareas farm-household models

The second representative farm is a holding of 60 tareas, 42.00 tareas of land type A and 18.00 tareas of land type B. Total labor availability amounts to 54.15 man-days per month. Available capital consists of RD$1680.00 in loans and RD$700.00 in cash assets. Nutritional requirements equal the recommended dietary allowance for an average family of six. Tables 5.11 through 5.17 present information about the optimal plan under both the net revenue and total output objective functions.

Table 5.11 presents the optimum land use pattern for the 60 tareas farm-household as well as the optimum consumption pattern which meets the recommended dietary allowance. The maximum net revenue is estimated at RD$9455.68 and total output is estimated at RD$10894.60. During the first period, land use includes 21.95 tareas of black beans (bbea13) on land type A with technology 3, 12.00 tareas of plantain on land type B with technology

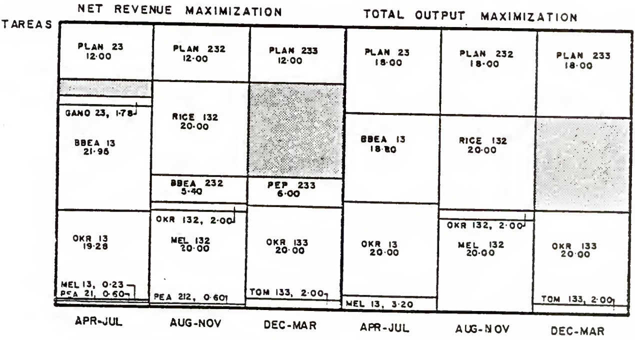

FIGURE 5·2: OPTIMAL 60 TAREAS FARM LAND USE PATTERN UNDER NET REVENUE AND TOTAL OUTPUT MAXIMIZATION

Table 5.11: Optimum 60 Tareas Farm-Household Plan for Production and Consumption under the Net Revenue and Total Output Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Net Revenue Activity level	Net Revenue Input cost	Net Revenue Food cost	Total Output Activity level	Total Output Input cost
Field crops						
1st period, Apr-Jul						
Bbea13	tarea	21.95	402.78	-	18.71	343.33
Gand23	tarea	1.78	36.49	-	0.0	0.0
Plan23	tarea	12.00	176.52	-	18.00	264.78
Okr13	tarea	19.28	1154.32	-	20.00	1164.80
Mel13	tarea	0.23	21.07	-	3.20	301.36
Pea21	tarea	0.60	10.90	-	0.0	0.0
2nd period, Aug-Nov						
Rice132	tarea	20.00	1453.60	-	20.00	1453.60
Bbea232	tarea	5.35	98.17	-	0.0	0.0
Plan232	tarea	12.00	44.16	-	18.00	66.24
Okr132	tarea	2.00	116.68	-	2.00	116.68
Mel132	tarea	20.00	1832.00	-	20.00	1832.00
Pea212	tarea	0.65	11.28	-	0.0	0.0
3rd period, Dec-Mar						
Plan233	tarea	12.00	44.16	-	18.00	66.24
Okr133	tarea	20.00	1166.80	-	20.00	1166.80
Tom133	tarea	2.00	70.74	-	2.00	70.74
Home consumption						
1st period, Apr-Jul						
Cgand	quintal	2.63				
Cmel	hundred	10.36				
Cpea	quintal	0.90				
2nd period, Aug-Nov						
Cpea2	quintal	0.97				
3rd period, Dec-Mar						
Cgand3	quintal	2.70				
Ctom3	quintal	16.82				
Food purchase						
1st period, Apr-Jul						
Frice	lbs	240.00	0.28	67.20		
Fpast	lbs	50.00	0.28	14.00		
Fcorn	lbs	150.00	0.14	21.00		
Fbean	lbs	80.00	0.38	30.40		
Fplan	lbs	400.00	0.10	40.00		
Fbeef	lbs	0.43	0.80	0.34		
Fchic	lbs	75.00	0.65	48.75		

Table 5.11 continued

Activity	Unit	Net Revenue Activity level	 Input cost	 Food cost
1st period, Apr-Jul				
Fcodf	lbs	48.40	1.02	49.37
Fmilk	bottle	60.00	0.66	36.00
Foil	lbs	24.00	1.20	28.80
Fsalt	lbs	10.00	0.10	1.00
2nd period, Aug-Nov				
Frice2	lbs	240.00	0.28	67.20
Fpast2	lbs	50.00	0.28	14.00
Fcorn2	lbs	150.00	0.14	21.00
Fyuc2	lbs	628.71	0.08	50.30
Fbean2	lbs	80.00	0.38	30.40
Fplan2	lbs	400.00	0.10	40.00
Fchic2	lbs	75.00	0.65	48.75
Fcodf2	lbs	48.59	1.02	49.56
Fmilk2	bottle	60.00	0.66	39.60
Foil2	lbs	24.00	1.20	28.80
3rd period, Dec-Mar				
Frice3	lbs	240.00	0.28	67.20
Fpast3	lbs	50.00	0.28	14.00
Fcorn3	lbs	150.00	0.14	21.00
Fbean3	lbs	80.00	0.38	30.40
Fplan3	lbs	400.00	0.10	40.00
Fchic3	lbs	75.00	0.65	48.75
Fcodf3	lbs	48.00	1.02	48.96
Fmilk3	bottle	60.00	0.66	39.60
Foil3	lbs	24.00	1.20	28.80
Fsalt3	lbs	10.00	0.10	1.00

level 3, 19.82 tareas of okra on land type A with technology level 3, 0.23 tareas of melon on land type A with technology level 3 and 0.60 tareas of peanuts on land type B with technology level 1. However, during the second period the black bean activity drops to only 5.35 tareas on land type B while rice is included in the program at a level of 20.00 tareas. In the third period, black beans are dropped from the optimal solution while rice is carried over from the second period into the third period so that rice occupies the land during the first two months of the third period. Figure 5.2 graphs the optimal land use pattern.

Home consumption and food purchase also are presented in table 5.11. Most of the nutrients for the family are provided by food purchase, which reflects the strong market orientation of farmers in the Azua plain. The diet is oriented basically towards foods high in protein and calories, such as rice (240 pounds), pasta (50 pounds), corn (150 pounds), beans (80 pounds) and codfish (80 pounds) during the first period.

Table 5.12 contains information on the normative distribution of the output in the optimal solution. For example, the total black bean output of 43.89 quintal is sold whereas the total pigeon pea (gand23) output is distributed as follows: home consumption 2.63 quintal and storage for future disposal 2.70 quintals.

The resources used to achieve the optimal plan are as follows (table 5.13). Under the net revenue maximization objective, all land is used except for 3.62 tareas of land type B during the first period and 20 tareas of land type B during the last three months of the last period. This is in part because rice132 is carried over into the third period occupying the land during the first month (figure 5.2).

Table 5.12: Optimal Field Crop Activities and Output Distribution under the Net Revenue Maximization Objective for the 60 Tareas Farm-Households, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level (tarea)	Total output	Sale	Home consumption	Storage
1st period, Apr-Jul						
Bbea13	quintal	21.95	43.89	43.89	-	-
Gand23	quintal	1.78	5.33	-	2.63	2.70
Plan23	thousand	12.00	10.20	10.20	-	-
Okr13	quintal	19.28	237.84	237.87	-	-
Mel13	hundred	0.23	10.35	-	10.36	-
Pea21	quintal	0.60	0.90	-	0.90	-
2nd period, Aug-Nov						
Rice132	quintal	20.00	163.59	74.99	-	88.60
Bbea232	quintal	5.35	10.70	10.70	-	-
Plan232	thousand	12.00	10.20	10.20	-	-
Okr132	quintal	2.00	24.00	24.00	-	-
Mel132	hundred	20.00	900.00	900.00	-	-
Pea212	quintal	0.65	0.97	-	0.97	-
3rd period, Dec-Jan						
Plan233	thousand	12.00	10.20	10.20	-	-
Pep233	quintal	6.00	72.00	72.00	-	-
Okr133	quintal	20.00	240.00	240.00	-	-
Tom133	quintal	2.00	81.27	64.47	16.80	-

Family labor is fully utilized since it is permitted to be sold when abundant. Also, labor is hired when the farm is short of family labor as is the case especially during the planting and the harvesting seasons. Capital availability is used up to its capacity.

Under the total output maximization objective all available resources are fully used except for land type A during the last three months of the last planning period. Again, rice 132 is carried over from the second period to the first month of the third period.

Table 5.13: Comparison of Resources Used, Non-Used and Shadow Prices for the Optimal 60 Tareas Farm-Household Plan, under the Net Revenue and Total Maximization Objectives, Azua, Dominican Republic, 1984.

Shadow Resource	Unit	Net Revenue			Total Output		
		Resources		Shadow price	Resources		price
		Used	Non used		Used	Non used	
Landa1	tarea	42.00	-	20.73	42.00	-	24.75
Landa2	tarea	42.00	-	-	42.00	-	-
Landa3	tarea	42.00	-	-	42.00	-	-
Landa4	tarea	42.00	-	-	42.00	-	-
Landb1	tarea	14.38	3.62	-	18.00	-	2.90
Landb2	tarea	14.38	3.26	-	18.00	-	-
Landb3	tarea	14.38	3.26	-	18.00	-	-
Landb4	tarea	14.38	3.26	-	18.00	-	-
Aprilab	man-day	54.15	-	5.75	54.15	-	5.29
Maylab	man-day	54.15	-	5.75	54.15	-	5.29
Junlab	man-day	54.15	-	5.57	54.15	-	5.29
Jullab	man-day	54.15	-	5.75	54.15	-	5.29
Finbal	pesos	720.00	-	0.44	720.00	-	0.32
Capbor	pesos	1680.00	-	0.32	1680.00	-	0.20
Landa5	tarea	42.00	-	-	42.00	-	50.50
Landa6	tarea	42.00	-	-	42.00	-	-
Landa7	tarea	42.00	-	50.50	42.00	-	-
Landa8	tarea	42.00	-	-	42.00	-	-
Landb5	tarea	18.00	-	33.89	18.00	-	-
Landb6	tarea	18.00	-	-	18.00	-	33.89
Landb7	tarea	18.00	-	-	18.00	-	-
Landb8	tarea	18.00	-	-	18.00	-	-
Auglab	man-day	54.15	-	4.00	54.15	-	4.00
Seplab	man-day	54.15	-	4.00	54.15	-	4.00
Octlab	man-day	54.15	-	4.00	54.15	-	4.00
Novlab	man-day	54.15	-	4.00	54.15	-	4.00
Landa9	tarea	42.00	-	-	42.00	-	12.53
Landa10	tarea	22.00	20.00	-	22.00	20.00	-
Landa11	tarea	22.00	20.00	-	22.00	20.00	-
Landa12	tarea	22.00	20.00	-	22.00	20.00	-
Landb9	tarea	18.00	-	-	18.00	-	31.38
Landb10	tarea	18.00	-	-	18.00	-	-
Landb11	tarea	18.00	-	-	18.00	-	-
Landb12	tarea	18.00	-	31.12	18.00	-	-
Declab	man-day	54.15	-	4.00	54.15	-	4.00
Janlab	man-day	54.15	-	4.00	54.15	-	4.00
Feblab	man-day	54.15	-	4.00	54.15	-	4.00
Marlab	man-day	54.15	-	4.00	54.15	-	4.00

Up to now only used and non-used resources have been considered. However, each resource fully utilized in the plan is limiting and is associated with a shadow price. Table 5.14 presents the information on the limiting resources and their shadow price as well as the range over which the shadow price is relevant. Interpretation is similar to the one of the 25 tareas farm plan. For example, April labor (Aprilab) is used to its limit of 54.15 man-days. Therefore, the marginal value product for April labor is RD$5.76 which is relevant over the range of -59.33 to 56.44. Each man-day reduction of labor from 54.15

Table 5.14: Marginal Value Productivities of Scarce Resources, and Range, under the Net Revenue Maxization Objective for the 60 Tareas Farm-Households, Azua, Dominican Republic, 1984.

Resource	Unit	Resource level	Shadow price	Range Shadow Price	
				lower	upper
Landa1	tarea	42.00	20.73	41.73	42.00
Aprilab	man-day	54.15	5.76	-59.33	56.44
Maylab	man-day	54.15	5.76	-59.33	56.44
Junlab	man-day	54.15	5.76	-35.80	56.44
Jullab	man-day	54.15	5.76	-59.33	56.44
Finbal	pesos	720.00	0.44	-266.07	729.14
Capbor	pesos	1680.00	0.32	-1226.07	1689.14
Landa7	tarea	42.00	50.50	40.00	42.00
Landb5	tarea	18.00	33.89	13.41	18.00
Auglab	man-day	54.15	4.00	-109.20	61.51
Seplab	man-day	54.15	4.00	-109.20	63.10
Octlab	man-day	54.15	4.00	-109.20	59.36
Novlab	man-day	54.15	4.00	-109.20	103.36
Landa9	tarea	42.00	12.53	41.78	47.46
Landb12	tarea	18.00	31.12	17.76	18.00
Declab	man-day	54.15	4.00	-1036.01	165.58
Janlab	man-day	54.15	4.00	37.40	976.86
Feblab	man-day	54.15	4.00	-1036.01	54.54
Marlab	man-day	54.15	4.00	-1036.01	139.52

to -59.33 man-days would reduce the value of the program by RD$5.76 (actually, since no real activity can have a negative value, the real range of the constant income penalty is from 0 to the present value). Each man-day added beyond 54.15 to 56.44 would add RD$5.76 to the value of the program.

Table 5.15 presents information on the stability of the optimal farm-household plan and on the penalty associated with diverging from the optimal solution. Pigeon peas (gand23), using land type B and technology 3 at a level of 1.78 tareas in the first period, has a variable cost of RD$20.50 per tarea. The income penalty for each tarea of pigeon peas used less than the optimum amounts to RD$1.26. If pigeon pea production is increased above the optimum, the penalty is RD$3.49 per tarea. This penalty applies up to 5.40 tareas. The "cost range column" provides an estimate of the sensitivity of pigeon peas to changes in the total variable cost (Cj). Pigeon peas have a variable cost of RD$20.50. This coefficient can vary from RD$17.01 to RD$21.76 before changes in the level of pigeon pea production would occur.

Information on the price range for the optimal solution is presented in table 5.16. The column "price range limit" provides estimates of the sensitivity of the

Table 5.15: Stability of the Optimal 60 Tarea Farm-Household Plan under the Net. Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Input cost (Cj)	Income penalty lower	Income penalty upper	Activity range limit lower	Activity range limit upper	Cost range limit lower	Cost range limit upper
Field crops									
Bbea13	tarea	21.59	18.35	1.26	0.49	21.57	22.22	17.56	19.97
Gand23	tarea	1.78	20.50	1.26	3.49	1.55	5.40	17.01	21.76
Plan23	tarea	12.00	14.71	3.07	0.28	11.80	12.48	14.43	17.78
Okr13	tarea	19.82	58.24	0.49	1.63	19.55	20.00	56.61	58.73
Mel13	tarea	0.23	91.60	157.72	9.77	0.23	12.48	81.83	249.32
Pea21	tarea	0.60	18.18	14.18	39.02	6.02	4.22	20.84	32.36
Rice132	tarea	20.00	72.68	34.77	inf	14.54	20.00	inf	107.45
Bbea232	tarea	5.35	18.35	0.28	3.07	4.88	5.55	15.28	18.63
Okr132	tarea	2.00	58.34	3.07	34.77	1.80	7.46	23.57	61.41
Mel132	tarea	20.00	91.60	47.50	inf	2.00	20.00	inf	139.10
Pea212	tarea	0.65	18.18	32.19	31.17	0.0	5.54	12.99	50.37
Pep233	tarea	6.00	43.00	0.28	3.07	5.52	6.20	39.93	43.28
Okr133	tarea	20.00	58.34	38.25	inf	12.69	20.00	inf	96.59
Tom133	tarea	2.00	35.37	3.07	4.80	1.80	2.00	30.57	38.44
Food purchase									
Frice	lbs	240.00	0.28	22.19	0.60	240.00	584.30	0.32	22.47
Fpast	lbs	50.00	0.28	inf	0.37	50.00	167.82	0.09	inf
Fcorn	lbs	150.00	0.14	15.90	0.18	149.10	238.91	0.04	16.04
Fbean	lbs	80.00	0.38	22.23	1.79	79.72	194.77	1.41	22.70
Fplan	lbs	400.00	0.10	inf	0.10	340.00	515.96	0.0	inf
Fbeef	lbs	0.43	0.80	0.63	0.41	-36.93	111.52	0.40	1.43
Fchic	lbs	75.00	0.65	inf	0.36	75.00	205.65	0.29	inf
Fcodf	lbs	48.00	1.02	0.19	1.35	10.79	56.77	0.33	1.20
Fmilk	bottle	60.00	0.66	0.68	0.61	38.33	195.15	0.05	1.34
Foil	lbs	24.00	1.20	inf	5.96	24.00	58.43	4.76	inf
Fsalt	lbs	10.00	0.10	0.18	inf	-2.02	10.00	inf	0.28
Frice2	lbs	240.00	0.28	inf	0.43	240.00	597.47	0.15	inf
Fpast2	lbs	50.00	0.28	inf	0.27	50.00	2074.15	0.01	inf
Fcorn2	lbs	150.00	0.14	16.87	0.13	140.95	2090.91	0.01	17.01
Fyuc2	lbs	628.71	0.08	0.04	0.08	-63497.80	4460.81	0.0	0.12
Fbean2	lbs	80.00	0.38	32.85	1.28	68.49	199.16	0.90	33.23
Fplan2	lbs	340.00	0.01	inf	0.04	400.00	1271.62	0.06	inf
Fchic2	lbs	75.00	0.65	inf	0.23	75.00	207.59	0.42	inf
Fcodf2	lbs	48.59	1.02	0.50	1.01	69.92	687.56	0.01	1.52
Fmilk2	bottle	60.00	0.66	1.06	0.52	12.93	527.83	0.14	1.72

Table 5.15 continued

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty		Activity Range Limit		Cost Range Limit	
				lower	upper	lower	upper	lower	upper
Food purchase									
Foil2	lbs	24.00	1.20	inf	4.26	24.00	59.75	3.06	inf
Frice3	lbs	240.00	0.28	22.41	0.45	236.07	417.68	0.17	22.69
Fpast3	lbs	50.00	0.28	inf	0.24	50.00	397.78	0.04	inf
Fcorn3	lbs	150.00	0.14	inf	0.12	150.00	1383.56	0.02	inf
Fbean3	lbs	80.00	0.38	inf	1.36	80.00	139.23	0.98	inf
Fplan3	lbs	400.00	0.10	inf	0.08	400.00	1540.58	0.02	inf
Fcnic3	lbs	75.00	0.65	inf	0.28	75.00	207.59	0.37	inf
Fcodf3	lbs	48.59	1.02	0.02	0.96	30.92	268.42	0.06	1.04
Fmilk3	bottle	60.00	0.66	0.19	0.39	46.08	145.16	0.27	0.85
Foil3	lbs	24.00	1.20	0.19	0.39	24.00	41.77	3.33	inf
Fsalt3	lbs	10.00	0.10	0.25	inf	-574.34	10.00	inf	0.35

inf = infinite

Table 5.16: Price Range for the Optimal 60 Tarea Farm-Household Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Sale price	Price Range Limit	
			lower	upper
Sbbea	quintal	35.00	35.00	35.15
Splan	thousand	50.00	24.11	50.33
Sokr	quintal	12.00	11.96	12.14
Srice2	quintal	26.00	26.00	26.00
Sbbea2	quintal	35.00	35.00	35.00
Splan2	thousand	50.00	0.50	50.33
Sokr2	quintal	12.00	11.74	14.90
Smel2	hundred	4.00	3.12	inf
Srice3	quintal	26.00	26.00	26.00
Splan3	thousand	50.00	7.68	50.33
Spep3	quintal	10.00	9.98	10.26
Sokr3	quintal	12.00	8.81	inf
Stom3	quintal	2.00	1.92	2.12

inf = infinite

quantity sold to changes in the price coefficients (Cj). Plantain (splan) is sold at a price of RD$50.00 per thousand. This coefficent can vary from RD$24.11 up to RD$50.33 before changes in the quantity sold would occur. This implies that the selling price for plantain could be reduced to RD$24.11 without a change in the amount of plantain sold.

Results for the 125 tarea farm-household models

As in the previous models, the objective is to maximize net revenue and total output subject to a set of constraints. Availability of land for the representative farm was set at 125 tareas of which 88.0 were classified as land type A and 37.00 tareas as land type B. Technology levels for this land were categorized as before, low, medium and high. Labor constraints were set at 54.15 man-days of labor per month. Capital availability was set at RD$5000.00, of which RD$1500.00 were considered cash assets and RD$3500.00 loans to the farm-household. Nutrition constraints equal the minimum recommended dietary allowance for a six member family. Information on the optimal solution of the model is presented in tables 5.17 through 5.22.

Optimum farmland use as well as home consumption and food purchase for the farm-household are presented in table 5.17 for both the net revenue and total output maximization objectives. Net revenue is estimated at RD$15,517.78 and total output at RD$16,618.60. During the first period, the level of field crops for the optimum solution is as follows: 12.14 tareas of corn on land type A with technology 3, 14.18 tareas of corn on land type B with technology 3, 25.85 tareas of black beans on land type A and technology 3, 0.42 tareas of pigeon peas (gand23) on land type B with technology 3, 21.35 tareas of plantain on land B with technology 3 and other food crops. Figure 5.3 graphs the optimal farmland use pattern for both objectives.

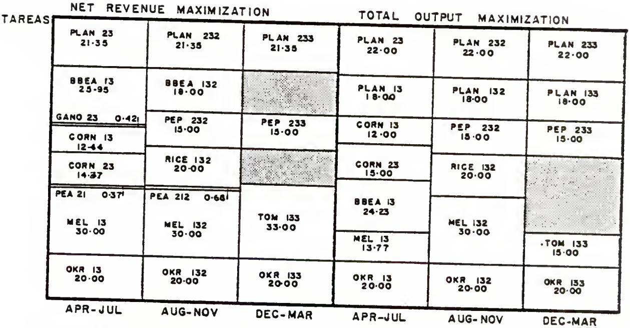

FIGURE 5·3: OPTIMAL 125 TAREAS FARM LAND USE PATTERN UNDER NET REVENUE AND TOTAL OUTPUT MAXIMIZATION

Table 5.17: Optimum 125 Tarea Farm-Household Plan for Production and Consumption under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984.

Activity	Unit	Net Revenue			Total Output	
		Activity level	Input cost	Food cost	Activity level	Input cost
Field crops						
1st period, Apr-Jul						
Corn13	tarea	12.14	198.25	-	12.00	195.96
Corn23	tarea	14.18	144.35	-	15.00	152.07
Bbea13	tarea	25.85	474.35	-	24.23	444.62
Gand23	tarea	0.42	8.61	-	-	-
Plan23	tarea	21.35	156.92	-	22.00	161.70
Okr13	tarea	20.00	1164.80	-	20.00	1164.80
Mel13	tarea	30.00	2748.00	-	13.77	1261.33
Pea21	tarea	0.37	6.73	-	-	-
2nd period, Aug-Nov						
Rice132	tarea	20.00	1453.60	-	20.00	1453.60
Bbea132	tarea	18.00	330.30	-	-	-
Plan232	tarea	21.35	78.57	-	22.00	80.96
Pep232	tarea	15.00	645.00	-	15.00	645.00
Okr132	tarea	20.00	1166.80	-	20.00	1166.80
Mel132	tarea	30.00	2748.00	-	30.00	2748.00
Pea212	tarea	0.64	11.64	-	-	-
3rd period, Dec-Mar						
Plan233	tarea	21.35	78.57	-	22.00	80.96
Pep233	tarea	15.00	645.00	-	15.00	645.00
Okr133	tarea	20.00	1166.80	-	20.00	1166.80
Tom133	tarea	33.00	1167.21	-	15.00	530.00
Home consumption						
1st period, Apr-Jul						
Cgand	quintal	0.96				
Cplan	thousand	0.01				
Cmel	hundred	10.36				
Cpean	quintal	1.00				
2nd period, Aug-Nov						
Cpean2	quintal	0.97				
3rd period, Dec-Mar						
Ccorn3	quintal	6.20				
Cgand3	quintal	0.28				
Ctom3	quintal	16.68				
Cpean3	quintal	0.92				
Food purchase						
1st period, Apr-Jul						
Frice	lbs	240.00	0.28	67.20		
Fpast	lbs	50.00	0.28	14.00		
Fcorn	lbs	150.00	0.14	21.00		

Table 5.17 continued

Activity	Unit	Net Revenue		
		Activity level	Input cost	Food cost
1st period, Apr-Jul				
Fbean	lbs	80.00	0.38	30.40
Fplan	lbs	400.00	0.10	40.00
Fbeef	lbs	5.43	0.80	4.34
Fchic	lbs	75.80	0.65	48.75
Fsard	lbs	76.09	1.10	83.70
Fmilk	bottle	60.00	0.66	39.60
Foil	lbs	24.00	1.20	28.80
Fsalt	lbs	10.00	0.10	1.00
2nd period, Aug-Nov				
Frice2	lbs	240.00	0.28	67.20
Fpast2	lbs	50.00	0.28	14.00
Fcorn2	lbs	150.00	0.14	21.00
Fyuc2	lbs	628.00	0.08	50.24
Fbean2	lbs	80.00	0.38	30.40
Fplan2	lbs	400.00	0.10	40.00
Fchic2	lbs	75.00	0.65	48.75
Fcodf2	lbs	48.59	1.02	49.56
Fmilk2	bottle	60.00	0.66	39.60
Foil2	lbs	24.00	1.20	28.80
3rd period, Dec-Mar				
Frice3	lbs	240.00	0.28	67.20
Fpast3	lbs	50.00	0.28	14.00
Fcorn3	lbs	150.00	0.14	21.00
Fbean3	lbs	80.00	0.38	30.40
Fplan3	lbs	400.00	0.10	40.00
Fchic3	lbs	75.00	0.65	48.75
Farren3	lbs	61.71	0.87	53.69
Fsard3	lbs	39.57	1.10	43.53
Fmilk3	bottle	60.00	0.66	39.60
Foil3	lbs	24.00	1.20	28.80
Fsalt3	lbs	10.00	0.10	1.00

Home consumption is kept very low so that a large proportion of the family food needs are purchased. As expected, most of the family food purchased consists of food with low prices and a high content of protein and calories. During the first planning period the recommended dietary allowance is met with a combination of eleven goods, of which rice (240 pounds), pasta (50 pounds), corn (150 pounds), beans (80 pounds), plantain (400 pounds and chicken (75 pounds) dominate the diet.

Table 5.18: Optimal Field Crop Activities and Output Distribution under the Net Revenue Maximization Objective for 125 Tarea Farm-Households, Azua, Dominican Republic, 1984.

Fieldcrop	Unit	Activity level	Total output	Sale	Home consumption	Storage
1st period, Apr-Jul						
Corn13	quintal	12.14	36.42	36.43	-	-
Corn23	quintal	14.18	28.36	28.37	-	-
Bbea13	quintal	25.85	51.70	-	-	51.71
Gand23	quintal	0.42	1.24	-	0.96	0.28
Plan23	thousand	21.35	18.16	18.15	0.01	-
Okr13	quintal	20.00	240.00	240.00	-	-
Mel13	hundred	30.00	1349.00	1339.63	10.36	-
Pea21	quintal	0.37	0.55	-	0.55	-
2nd period, Aug-Nov						
Rice132	quintal	20.00	163.36	163.36	-	-
Bbea132	quintal	18.00	36.00	30.00	6.00	-
Plan232	thousand	21.35	18.15	18.15	-	-
Pep232	quintal	15.00	180.00	180.00	-	-
Okr132	quintal	20.00	240.00	240.00	-	-
Mel132	hundred	30.00	1620.00	1620.00	-	-
Pea212	quintal	0.64	0.97	-	0.97	-
3rd period, Dec-Mar						
Plan233	thousand	21.35	18.15	18.15	-	-
Pep233	quintal	15.00	180.00	180.00	-	-
Okr133	quintal	20.00	264.00	240.00	-	-
Tom133	quintal	33.00	1340.68	1324.00	16.68	-

Table 5.18 presents information on how farm output is distributed over sale, home consumption and storage for future disposal. During the first period, for example, total corn output is sold immediately after the harvest, whereas 0.96 quintal of pigeon peas (gand23) is consumed by the family and 0.28 quintal is stored. No pigeon peas are sold. However, most crops are cashcrops, implying that most family foodstuffs must be purchased.

Data on the amount of resources used and not used in the production process are presented in table 5.19. Land is fully utilized under the net revenue maximization objective function during the first two planning periods, during the third period 35.00 tareas of land type A and 0.65 tareas of land type B remain idle. Under the total output maximization objective, 35.00 tareas of land type A remain idle during the last period (Nov-Mar).

The shadow price column gives the marginal value product for each one of the limiting resources. With this information the most valuable resources in terms of farm income can be identified. In November land type B with a value of RD$43.00 is the most valuable resource under the net revenue objective function. This means that in November, an additional tarea of land type B would add RD$43.00 to the net revenue. Under the total output maximization objective, the most valuable resource is land type A in September (landa6), which has a shadow price of RD$45.19.

Table 5.19: Comparison of Resources Used, Non-Used and Shadow Prices for the Optimal 125 Tarea Farm-Household Plan under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984.

Resource	Unit	Net Revenue			Total Output		
		Resources		Shadow price	Resources		Shadow price
		Used	non-used		Used	non-used	
Landa1	tarea	88.00	-	-	88.00	-	-
Landa2	tarea	88.00	-	-	88.00	-	-
Landa3	tarea	88.00	-	-	88.00	-	-
Landa4	tarea	88.00	-	31.66	88.00	-	12.75
Landb1	tarea	37.00	-	31.06	37.00	-	-
Landb2	tarea	37.00	-	-	37.00	-	-
Landb3	tarea	37.00	-	-	37.00	-	-
Landb4	tarea	37.00	-	-	37.00	-	25.37
Aprilab	man-day	54.15	-	4.48	54.15	-	5.29
Maylab	man-day	54.15	-	4.48	54.15	-	5.29
Junlab	man-day	54.15	-	4.48	54.15	-	5.29
Jullab	man-day	54.15	-	4.48	54.15	-	5.29
Finbal1	pesos	1500.00	-	0.12	1500.00	-	0.32
Capbor	pesos	3500.00	-	0.20	3500.00	-	0.20
Landa5	tarea	88.00	-	42.13	88.00	-	-
Landa6	tarea	88.00	-	-	88.00	-	45.19
Landa7	tarea	88.00	-	-	88.00	-	-
Landa8	tarea	88.00	-	-	88.00	-	-
Landb5	tarea	37.00	-	-	22.00	15.00	-
Landb6	tarea	37.00	-	-	22.00	15.00	-
Landb7	tarea	37.00	-	-	22.00	15.00	-
Landb8	tarea	37.00	-	43.00	37.00	-	33.89
Auglab	man-day	54.15	-	4.00	54.15	-	4.00
Seplab	man-day	54.15	-	4.00	54.15	-	4.00
Octlab	man-day	54.15	-	4.00	54.15	-	4.00
Novlab	man-day	54.15	-	4.00	54.15	-	4.00
Landa9	tarea	88.00	-	12.53	88.00	-	12.53
Landa10	tarea	53.00	35.00	-	53.00	35.00	-
Landa11	tarea	53.00	35.00	-	53.00	35.00	-
Landa12	tarea	53.00	35.00	-	53.00	35.00	-
Landb9	tarea	36.35	0.65	-	37.00	-	8.90
Landb10	tarea	36.35	0.65	-	37.00	-	-
Landb11	tarea	36.35	0.65	-	37.00	-	-
Landb12	tarea	36.35	0.65	-	37.00	-	-
Declab	man-day	54.15	-	4.00	54.15	-	4.00
Janlab	man-day	54.15	-	4.00	54.15	-	4.00
Feblab	man-day	54.15	-	4.00	54.15	-	4.00
Marlab	man-day	54.15	-	4.00	54.15	-	4.00

This information, however, only reports how much one additional unit of a limiting resource would add to the plan, but does not say anything about how many units can be added. This additional information can be found in table 5.20, where marginal value productivities of limiting resources and the range over which they are valid is presented. For example, May labor (Maylab) has an activity level of 54.15 man-days with a shadow price of RD$4.49. The column range shadow price shows the range over which this price is relevant. Each man-day of labor reduced down from

Table 5.20: Marginal Value Productivities of Scarce Resources, and Range, for 125 Tarea Farm-Households, Azua, Dominican Republic, 1984.

Resource	Unit	Resource level	Shadow price	Range Shadow Price lower	Range Shadow Price upper
Landa4	tarea	88.00	31.66	62.14	88.00
Landb1	tarea	37.00	31.08	22.14	37.00
Aprilab	man-day	54.15	4.49	-935.90	124.65
Maylab	man-day	54.15	4.49	-953.90	169.01
Junlab	man-day	54.15	4.49	-935.90	85.48
Jullab	man-day	54.15	4.49	-935.90	274.94
Finbal	pesos	1500.00	0.12	-2460.20	7039.80
Landa5	tarea	88.00	42.13	70.00	88.00
Landb8	tarea	37.00	43.00	26.86	37.65
Auglab	man-day	54.15	4.00	-193.58	146.49
Seplab	man-day	54.15	4.00	-193.58	121.16
Octlab	man-day	54.15	4.00	-193.58	138.81
Novlab	man-day	54.15	4.00	-193.58	348.73
Landa9	tarea	88.00	12.53	55.82	97.71
Declab	man-day	54.15	4.00	-339.86	189.75
Janlab	man-day	54.15	4.00	-339.86	152.95
Feblab	man-day	54.15	4.00	-339.86	131.73
Marlab	man-day	54.15	4.00	-339.86	305.84

54.15 man-days to -935.90 man-days (in fact to zero man-days) would reduce the value of the program by RD$4.49. Each man-day added beyond 54.15 to 169.01 man-days would add RD$4.49 to the net revenue.

Table 5.21 presents information on the stability of the optimal solution and the income penalty when diverging from it. Corn on land type A with technology 3 (corn13) is in the solution at a level of 12.14 tareas. The variable cost (Cj) in the objective function is RD$16.33. The column "income penalty" indicates that an income penalty of RD$0.54 occurs for each tarea the activity is reduced below the optimum. A higher penalty applies if the area planted decreases from 12.14; if more than 12.14 tareas are used for the production of corn13, the penalty is RD$2.39.

A similar interpretation should be given to the food purchase activities. For example, the level of corn purchased in period one (fcorn) is 150 pounds. The cost per pound is RD$0.14. A decrease below 150 pounds has an income penalty of RD$0.14 for each pound purchased below the optimal down to 148 pounds.

Table 5.22 presents information on prices and an estimate of the sensitivity of the quantities sold to changes in the prices. It should be noted that the selling price of melon (smel) is RD$4.00 per hundred. This coefficient can vary from RD$3.87 up to RD$6.61 before changes in the level of melon sale occur.

Table 5.21: Stability of the Optimal 125 Tarea Farm-Household Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Field crops									
Corn13	tarea	12.14	16.33	0.54	2.39	12.14	12.14	13.94	16.87
Corn23	tarea	14.56	10.18	2.39	0.54	14.86	14.86	9.46	12.57
Bbea13	tarea	25.86	18.35	0.29	5.48	7.86	25.95	12.87	18.46
Gand23	tarea	0.42	20.50	5.48	2.39	0.32	0.42	18.11	25.98
Plan23	tarea	21.35	14.71	9.11	7.23	11.21	22.00	7.48	23.82
Okr13	tarea	20.00	58.42	16.42	inf	13.12	20.00	inf	74.66
Mel13	tarea	30.00	91.60	16.80	inf	24.49	30.00	inf	108.40
Pea21	tarea	0.37	18.18	17.83	50.79	-11.77	0.53	32.61	36.01
Rice132	tarea	2.68	72.68	37.72	inf	-5.16	20.00	inf	110.40
Bbea132	tarea	18.00	18.35	0.29	8.37	-3.93	25.63	9.98	18.64
Pep232	tarea	15.00	0.0	7.23	inf	14.35	15.00	inf	7.23
Okr132	tarea	20.00	58.34	8.37	inf	12.37	20.00	inf	66.71
Mel132	tarea	30.00	91.60	55.87	inf	24.34	30.00	inf	147.47
Pea212	tarea	0.65	18.18	19.13	40.28	0.0	10.79	22.10	37.31
Pep233	tarea	15.00	43.00	31.12	inf	0.0	15.00	inf	74.12
Okr133	tarea	20.00	58.34	38.25	inf	0.0	20.00	inf	96.59
Tom133	tarea	33.00	35.37	0.29	7.23	15.00	33.65	28.14	35.66
Food purchase									
Frice	lbs	240.00	0.28	21.20	0.38	240.00	356.50	0.10	21.48
Fpast	lbs	50.00	0.28	inf	0.26	50.00	547.88	0.02	inf
Fcorn	lbs	150.00	0.14	4.79	0.13	148.00	347.65	0.01	4.93
Fbean	lbs	80.00	0.38	18.95	1.14	79.60	118.83	0.76	19.33
Fplan	lbs	400.00	0.10	inf	0.07	400.00	829.55	0.03	inf
Fbeef	lbs	5.43	0.80	0.59	0.44	-28.26	25.91	0.36	1.39
Fchic	lbs	75.00	0.65	inf	0.40	75.00	102.55	0.25	inf
Fsard	lbs	76.09	1.10	0.17	0.42	50.33	97.44	0.68	1.27
Fmilk	bottle	60.00	0.66	0.18	0.42	35.59	208.51	0.24	0.84
Foil	lbs	24.00	1.20	inf	3.80	24.00	35.65	2.60	inf
Fsalt	lbs	10.00	0.10	0.31	inf	-8.72	10.00	inf	0.41
Frice2	lbs	240.00	0.28	inf	0.41	240.00	597.47	0.13	inf
Fpast2	lbs	50.00	0.28	inf	0.27	50.00	3252.28	0.01	inf
Fcorn2	lbs	150.00	0.14	6.07	0.13	150.00	2139.98	0.01	6.21
Fyuc2	lbs	628.71	0.08	0.04	0.08	-63497.80	6525.73	0.0	0.12
Fbean2	lbs	80.00	0.38	32.70	1.23	39.89	199.16	0.85	33.08
Fplan2	lbs	400.00	0.10	inf	0.04	340.00	1271.62	0.06	inf
Fchic2	lbs	75.00	0.65	inf	0.22	75.00	207.59	0.43	inf
Fcodf2	lbs	48.59	1.02	0.45	1.01	-69.92	1031.52	0.01	1.47

Table 5.21 continued

Activity	Unit	Activity	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Food purchase									
Fmilk2	bottle	60.00	0.66	1.03	0.51	-12.93	527.83	0.15	1.69
Foil2	lbs	24.00	1.20	inf	4.10	24.00	59.75	2.90	inf
Frice3	lbs	240.00	0.28	17.62	0.38	239.64	262.19	0.10	17.90
Fpast3	lbs	50.00	0.28	inf	0.19	50.00	84.60	0.09	inf
Fcorn3	lbs	150.00	0.14	inf	0.08	150.00	189.50	0.06	inf
Fbean3	lbs	80.00	0.38	inf	1.13	80.00	87.40	0.75	inf
Fplan3	lbs	400.00	0.10	inf	0.07	400.00	568.68	0.03	inf
Fchic3	lbs	75.00	0.65	inf	0.31	75.00	105.67	0.34	inf
Farren3	lbs	61.71	0.87	0.01	0.02	61.71	61.71	0.85	0.88
Fsard3	lbs	39.57	1.10	0.02	0.02	39.57	39.57	1.08	1.12
Fmilk3	bottle	60.00	0.66	0.13	0.38	27.38	249.52	0.28	0.79
Foil3	lbs	24.00	1.20	inf	3.76	24.00	26.22	2.56	inf
Fsalt	lbs	10.00	0.10	0.29	inf	-29.86	10.00	inf	0.39

inf = infinite

Table 5.22: Price Range for the Optimal 125 Tarea Farm-Household Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Sale price	Price Range Limit lower	Price Range Limit upper
Scorn	quintal	7.25	7.25	9.64
Splan	thousand	50.00	39.28	50.34
Sokr	quintal	12.00	10.63	inf
Smel	hundred	4.00	3.87	6.61
Srice2	quintal	26.00	26.00	inf
Splan2	thousand	50.00	39.28	50.43
Spep2	quintal	10.00	9.40	inf
Sokr2	quintal	12.00	11.30	inf
Smel2	hundred	4.00	2.97	inf
Sbbea3	quintal	35.00	35.00	37.28
Splan3	thousand	50.00	39.28	50.34
Spep3	quintal	10.00	7.41	inf
Sokr3	quintal	12.00	8.81	inf
Stom3	quintal	2.00	1.99	2.13

inf = infinite

Optimal Regional Farmland Use and Resource Allocation Plan

The first part of this chapter has presented the results for a set of individual representative farm-households. The purpose of the following section is to present the results at the regional level and to interpret their significance. The objective of the regional model is to optimize land use in terms of two explicit objective functions, net revenue and total output. Restrictions for the DLP models are the regional availability of a) irrigated land, which is set at 356,926 tareas of which 256,987 are classified as land type A and 99,934 are classified as land type B; b) family labor, estimated to be 245,355 man-days per month; c) capital, an estimated DR$14,277,040; and d) nutritional requirements for which the estimate is based on the recommended dietary allowance and the number of family households to be settled in the newly irrigated area. The details have been presented in chapter IV. The results obtained by the optimal plan of the regional models under both net revenue and total output are presented in tables 5.23 through 5.28.

Table 5.23 presents information on the optimum regional land use and consumption under the net revenue and total output maximization objectives. Regional net revenue is estimated at RD$28,416,812 while total output is estimated at RD$34,026,642. Activities included in the optimal program under the net revenue maximization objective are corn23, 35,000 tareas; sorg23, 25000 tareas; Plan13, 132,107 tareas; yuc23, 8000 tareas; tom13, 123,000 tareas and other first period short cycle food crops.

Some changes occur in land use under the total output maximization objective. For example, the amount of land allocated to plantain is increased from 132,107 tareas to 136,175 tareas; the type of land used has been changed also. In the first case, all plantain is grown on land type A; in the second case 87,237 tareas of land type A and 48,939 tareas of land type B are used. Black beans (bbea13) and pigeon peas (gand23) are dropped from the optimal solution under the total output maximization objective. This is due in part to their relatively low market price.

During the last period, sorghum (sorg233) is increased substantially under the net revenue maximization objective whereas the level of tomatoes is reduced. Under total output maximization, however, sorghum remains at the same level, whereas tomatoes are increased to a level of 75,320 tareas. This can be explained in terms of the objective of the farm-households. In the case of net revenue maximization, interest is not only in cash earnings but also in family nutritional requirements. When total output maximization is the objective, the market value of the crops is more important than the nutritional content of the crops.

Table 5.23: Optimum Regional Land Use and Consumption under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984.

Activity	Unit	Net Revenue			Total Output	
		Activity level	Input cost	Food cost	Activity level	Input cost
Field crops						
1st period, Apr-Jul						
Corn13	tarea	-	-		35000	571550
Corn23	tarea	35000	356300		-	-
Sorg23	tarea	25000	429000		25000	429000
Rice13	tarea	12000	872160		12000	872160
Rbea13	tarea	25000	566750		25000	566750
Bbea13	tarea	145	2665		-	-
Gand23	tarea	2181	44718		-	-
Plan13	tarea	132107	1943291		87237	641194
Plan23	tarea	-	-		48939	359702
Yuc23	tarea	8000	125840		8000	125840
Pep23	tarea	18000	774000		18000	774000
Okr13	tarea	18320	1066957		18320	1066957
Mel13	tarea	26292	2408349		36307	3325692
Tom13	tarea	43123	1525261		43123	1525261
Pea21	tarea	1667	30303		-	-
2nd period, Aug-Nov						
Corn132	tarea	-	-		14253	232751
Corn232	tarea	35000	356300		20747	211204
Sorg132	tarea	3560	61090		25000	429000
Sorg232	tarea	21440	367904		-	-
Rice132	tarea	12000	872160		12000	872160
Rbea132	tarea	25000	566750		25000	566750
Bbea132	tarea	18000	330300		18000	330300
Plan132	tarea	132107	486153		87237	321033
Plan232	tarea	-	-		48939	180096
Pep232	tarea	22253	956879		22253	956879
Oni132	tarea	8000	574960		17177	1234488
Okr132	tarea	18320	1068789		18320	1068789
Mel132	tarea	22000	2015200		22000	2015200
Pea212	tarea	3155	57366		-	-
3rd period, Dec-Mar						
Sorg233	tarea	63001	1081095		25000	429000
Rbea123	tarea	25000	699750		25000	699750
Plan133	tarea	132107	486153		87237	321033
Plan233	tarea	-	-		48939	180096
Pep233	tarea	18000	774000		18000	774000
Okr133	tarea	18000	1050120		18000	1050120
Tom133	tarea	39627	1401615		75320	2664068
Pea133	tarea	747	9155		-	-

Table 5.23 continued

Activity	Unit	Net Revenue		
		Activity level	Input cost	Food cost
Home consumption				
1st period, Apr-Jul				
Cgand	quintal	6544		
Cmel	hundred	25397		
Cpean	quintal	2500		
2nd period, Aug-Nov				
Cgand2	quintal	826870		
Cpean2	quintal	4733		
3rd period, Dec-Mar				
Ccorn3	quintal	930		
Ctom3	quintal	76698		
Cpean3	quintal	725		
Food Purchase				
1st period, Apr-Jul				
Frice	lbs	1070640	0.28	299779
Fpast	lbs	223050	0.28	62454
Fcorn	lbs	669150	0.14	93681
Fbean	lbs	356880	0.38	135614
Fplan	lbs	1784400	0.10	178440
Fbeef	lbs	24913	0.80	19931
Fchic	lbs	334575	0.65	217474
Fsard	lbs	384701	1.10	423172
Foil	lbs	107064	1.20	128477
Fsalt	lbs	44610	0.10	4461
2nd period, Aug-Nov				
Frice2	lbs	1070640	0.28	299779
Fpast2	lbs	223050	0.28	62454
Fcorn2	lbs	669150	0.14	93681
Fbean2	lbs	356880	0.38	135614
Fplan2	lbs	1784400	0.10	178440
Fchic2	lbs	334575	0.65	217474
Fcodf2	lbs	244539	1.02	249430
Foil2	lbs	107064	1.20	128455
3rd period, Dec-Mar				
Frice3	lbs	1070640	0.28	299779
Fpast3	lbs	223050	0.28	62454
Fcorn3	lbs	669150	0.14	93681
Fbean3	lbs	356880	0.38	135614
Fplan3	lbs	1784400	0.10	178440
Fchic3	lbs	334575	0.65	217474
Farren3	lbs	514631	0.87	447729
Fsard3	lbs	65569	1.10	72126
Foil3	lbs	107064	1.20	128477
Fsalt3	lbs	44610	0.10	4461

The optimal results for the region are consistent with the earlier results for representative individual farms. Home consumption is kept relatively low and always the same few crops are included in the program, pigeon peas being the most important one. Figure 5.4 graphs the optimal regional land use pattern under the net revenue and total output maximization objectives.

Another important aspect of the optimal plan is the diet of the population. Food needs, whether farm grown or purchased, link people to the land. In the model, family food has a priority. It is introduced as a set of nutrients that the family has to meet. Each item consumed by the family is evaluated in terms of cost and nutrient contents. Taken into account first was the nutrient need of the family according to the RDAs. Once the "nutrient package" was established, the model determined which foods would meet this nutrient package in terms of cost and nutritional content. Palatability of the diet was considered by limiting the set of foods to those traditionally used by the family which are either locally grown or locally sold at the market. Table 5.23 presents information on the optimal home consumption and food purchase activity levels that meet the nutritional requirements in the region. For example, during the first period, 1,070,690 pounds of rice (frice) are purchased and consumed at a cost of RD$299,779,

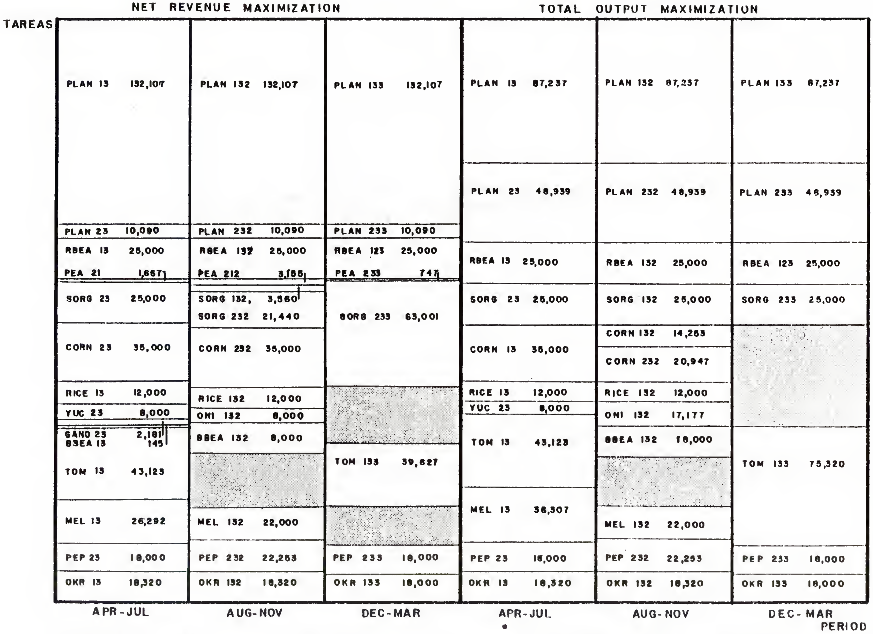

FIGURE 5.4: OPTIMAL REGIONAL LAND USE PATTERN UNDER NET REVENUE AND TOTAL OUTPUT MAXIMIZATION

and 223,050 pounds of pasta are purchased at a cost of RD$621,454.

Table 5.24 presents information on how regional output is distributed among sale, home consumption and storage for future disposal. It should be noted that market-oriented crops dominate the program and that home consumption is inconsequential for most crops.

Table 5.25 will be used to discuss the resources used, non-used and the shadow prices associated with them. During the first period (April-July) land resources are fully utilized under both the net revenue and total output maximization objectives. During the second period, 18,000 tareas of land type A and 22,254 tareas of land type B are not used under the net revenue maximization objective, while only 18,000 tareas of land type A are not used under total output maximization. In the third period around 51,000 tareas of land are not used under the net revenue maximization objective, while 62,253 tareas are not used in January and February and 95,250 tareas in March under the total output maximization objective. Family labor was utilized fully in all periods under both the net revenue and total output maximization objectives. Additional labor was hired at RD$4.00 per man-day. The capital available also was fully utilized under both net revenue and total output objective functions.

Table 5.24: Field Crop Activities and Output Distribution under the Net Revenue Maximization Objective for the Regional Model, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level (tarea)	Total output	Sale	Home consumption	Storage
Field crop						
1st period, Apr-Jul						
Corn23	quintal	35000	70000	-	-	70000
Sorg23	quintal	25000	100000	100000	-	-
Rice13	quintal	12000	98160	98160	-	-
Rbea13	quintal	25000	37500	-	-	37500
Bbea13	quintal	145	290	-	-	290
Gand23	quintal	2181	6544	-	6544	-
Plan13	thousand	132107	112291	112290	-	-
Plan23	thousand	10091	8577	8577	-	-
Yuc23	quintal	8000	61360	61360	-	-
Pep23	quintal	18000	216000	216000	-	-
Okr13	quintal	18320	219840	219840	-	-
Mel13	hundred	26292	1183141	1157744	25396	-
Tom13	quintal	43123	1752950	1752950	-	-
Pea21	quintal	1667	2500	-	2500	-
2nd period, Aug-Nov						
Corn232	quintal	35000	70000	70000	-	-
Sorg132	quintal	3560	14240	14240	-	-
Sorg232	quintal	21440	85759	85759	-	-
Rice132	quintal	12000	98160	98160	-	-
Rbea132	quintal	25000	37500	-	-	37000
Bbea132	quintal	18000	36000	36000	-	-
Plan13	thousand	132107	112291	112291	-	-
Plan23	thousand	10091	8577	8577	-	-
Pep232	quintal	22253	267036	267036	-	-
Oni132	quintal	8000	105600	105600	-	-
Okr132	quintal	18320	219840	219840	-	-
Mel132	hundred	22000	990000	990000	-	-
Pea212	quintal	3155	4733	-	4733	-
3rd period, Dec-Mar						
Sorg233	quintal	63001	252000	252403	-	-
Rbea123	quintal	25000	32250	32250	-	-
Plan13	thousand	132107	112291	112291	-	-
Plan23	thousand	10091	8577	8577	-	-
Pep233	quintal	18000	216000	216000	-	-
Okr133	quintal	18000	216000	216000	-	-
Tom133	quintal	39627	1610847	1534149	76698	-
Pea233	quintal	747	724	-	725	-

Table 5.25: Comparison of Resources Used, Not-Used and Shadow Prices for the Regional Farmland Plan under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984.

Resource	Unit	Net Revenue			Total Output		
		Resources		Shadow price	Resources		Shadow price
		used	non-used		used	non-used	
Landa1	tarea	256987	-	-	256987	-	-
Landa2	tarea	256987	-	36.32	256987	-	-
Landa3	tarea	256987	-	-	256987	-	-
Landa4	tarea	256987	-	-	256987		46.49
Landb1	tarea	99939	-	-	99939	-	-
Landb2	tarea	99939	-	-	99939	-	-
Landb3	tarea	99939	-	35.81	99939	-	-
Landb4	tarea	99939	-	-	99939	-	46.36
Aprilab	man-day	245355	-	4.89	245355	-	4.55
Maylab	man-day	245355	-	4.89	245355	-	4.55
Junlab	man-day	245355	-	4.89	245355	-	4.55
Jullab	man-day	245355	-	4.89	245355	-	4.55
Finbal	pesos	4283111	-	0.22	4283111	-	0.14
Capbor	pesos	9993928	-	0.10	11074203	-	0.02
Landa5	tarea	256987	-	35.36	256987	-	26.72
Landa6	tarea	238987	18000	-	238987	18000	-
Landa7	tarea	238987	18000	-	238987	18000	-
Landa8	tarea	238987	18000	-	238987	18000	-
Landb5	tarea	77686	22253	-	77686	22253	-
Landb6	tarea	77686	22253	-	77686	22253	-
Landb7	tarea	77686	22253	-	77686	22253	-
Landb8	tarea	99939	-	34.96	99939	-	26.94
Auglab	man-day	245355	-	4.00	245355	-	4.00
Seplab	man-day	245355	-	4.00	245355	-	4.00
Octlab	man-day	245355	-	4.00	245355	-	4.00
Novlab	man-day	245355	-	4.00	245355	-	4.00
Landa9	tarea	256987	-	12.53	256987	-	12.53
Landa10	tarea	214737	42253	-	194734	62253	-
Landa11	tarea	214737	42253	-	194734	62253	-
Landa12	tarea	189734	-	-	169734	87253	-
Landb9	tarea	99191	747	-	99939	-	-
Landb10	tarea	99191	747	-	99939	-	0.28
Landb11	tarea	99939	-	0.28	99939	-	-
Landb12	tarea	91939	8000	-	91939	8000	-
Declab	man-day	245355	-	4.00	245355	-	4.00
Janlab	man-day	245355	-	4.00	245355	-	4.00
Feblab	man-day	245355	-	4.00	245355	-	4.00
Marlab	man-day	245355	-	4.00	245355	-	4.00
Capinv	pesos	4283112	-	-	4283112	-	-

Marginal value products of restrictive resources are presented in the column of shadow prices. Non-restrictive resources are priced at zero because additional units of such resources would not influence the objective of the optimal plan. The most valuable resources in terms of the net revenue maximization objective is land type A in May (landa2) which is priced at RD$36.32. This means that an additional unit of land in May would increase tne value of the objective function by RD$36.32. Under the total output maximization objective the most valuable resources are July land type A and June land type B which have a shadow price of RD$46.49 and RD$46.36 respectively.

Table 5.26 is concerned with the range over which the shadow price is relevant. For example, the activity level column presents the resources used that are limiting the optimal solution at the regional level. Landa2 is reported to have a level of 256,986 tareas which is the upper limit of this resource; therefore, it is binding the optimal solution. Each tarea of May land reduced from 256,986 to 256,839 tareas would reduce the value of the regional program by RD$36.32. Each tarea added beyond 256,986 would add RD$36.32 to the value of the program. Interpretation of the shadow prices of other resources at the regional level is the same.

Table 5.26: Marginal Value Productivities of Scarce Resources, and Range, under the Net Revenue Maximization Objective for the Region, Azua, Dominican Republic, 1984.

Resource	Unit	Resource level	Shadow price	Range Shadow Price	
				lower	upper
Landa2	tarea	256987	36.32	256839	256987
Landb3	tarea	99939	35.81	99804	99939
Aprilab	man-day	245355	4.89	116691	249708
Maylab	man-day	245355	4.89	116691	249708
Junlab	man-day	245355	4.89	116691	249708
Jullab	man-day	245355	4.89	116691	249708
Finbal	pesos	4283109	0.22	3768453	4300521
Capbor	pesos	9993925	0.10	9479270	10011337
Landa5	tarea	256987	35.36	252305	257161
Landb8	tarea	99939	34.96	95258	100113
Auglab	man-day	245355	4.00	-1862920	357492
Seplab	man-day	245355	4.00	-1862920	288184
Octlab	man-day	245355	4.00	235963	inf
Novlab	man-day	245355	4.00	-1862918	532290
Landa9	tarea	256987	12.53	247989	259744
Landb11	tarea	99939	0.28	69131	100686
Declab	man-day	245355	4.00	240490	610582
Janlab	man-day	245355	4.00	133462	289892
Feblab	man-day	245355	4.00	133462	290874
Marlab	man-day	245355	4.00	133462	533505

inf = infinite

Optimal regional activity levels and resources up to this point have been discussed in terms of net revenue and total output maximization. Nothing has been said about the stability of the optimal solution. Table 5.27 presents information on the stability of the optimal solution under the net revenue maximization objective. The input cost column contains the variable cost coefficients (Cj) that are associated with the different activities. The column cost range limit provides an estimate of the sensitivity of each activity to changes in variable cost (Cj) coefficients. Note that corn23 has a Cj coefficient of -RD$10.18. This coefficient can vary up to RD$41.69 before a change in the level of corn23 would occur in the solution. This information is very important at the regional level because of its use in setting price policies for inputs responsible to increase the value of Cj.

Policy-makers can diverge from the plan for any activity by including the activity at a level either higher or lower than specified in the optimum regional plan. It is valuable to obtain insights into the magnitude of the income penalties associated with departing from the optimum. The income penalty column provides this information. Note that sorg23 is in the solution at a level of 25,000 tareas, the income penalty column indicates that an income penalty of RD$0.54 arises for each tarea the sorg23 is decreased below the optimum, which applies until the acreage reaches 20,850 tareas. The penalty becomes greater below this level. If production is raised beyond the optimum, the penalty is RD$37.23 per tarea. The same penalty applies up to 25,162 tareas. This is so because forcing more units of land to go into sorg23 production will force other more profitable activities out of production.

Table 5.27: Stability of the Optimal Regional Farmland Plan under the Net Revenue Maximization Objective, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Field crops									
Corn23	tarea	35000	10.18	0.54	51.87	30391	35167	41.69	-10.72
Sorg23	tarea	25000	17.16	0.46	37.23	20850	25162	20.07	-17.62
Rice13	tarea	12000	72.68	32.38	inf	-	12000	inf	-105.07
Rbea13	tarea	25000	22.67	12.98	21.66	21440	25210	-1.01	-35.65
Bbea13	tarea	145	18.35	2.46	3.68	145	821	-14.67	-20.81
Gand23	tarea	2181	20.50	16.22	3.59	2181	2181	-16.91	-36.72
Plan13	tarea	132107	7.35	0.46	1.93	127957	132107	-12.78	-15.17
Plan23	tarea	10099	7.35	3.59	0.46	10091	14241	-14.25	-18.30
Yuc23	tarea	8000	15.73	12.96	82.87	-	11771	67.14	-28.69
Pep23	tarea	18000	43.00	6.58	64.26	12302	21560	21.26	-49.58
Okr13	tarea	18320	58.24	2.90	inf	18000	18320	inf	-61.14
Mel13	tarea	26292	91.60	3.68	3.95	25616	26527	-87.65	-95.28
Tom13	tarea	43123	35.37	27.83	126.03	40036	43769	90.66	-63.20
Pea21	tarea	1667	18.18	19.56	56.88	-2413	1700	38.70	-37.74
Corn232	tarea	35000	10.18	0.62	46.12	31440	40518	35.94	-10.80
Sorg132	tarea	3560	17.16	0.62	0.46	-31440	7710	-16.70	-17.78
Sorg232	tarea	21440	17.16	0.46	0.62	17290	25000	-16.54	-17.62
Rice132	tarea	12000	72.68	37.72	inf	7775	12000	inf	-110.40
Rbea132	tarea	25000	22.67	6.73	17.91	18738	28041	-4.76	-29.40
Bbea132	tarea	18000	18.35	6.77	inf	17826	18000	inf	-25.12
Plan13	tarea	132107	3.68	0.46	1.93	127956	132107	12.78	15.17
Plan23	tarea	10099	3.68	0.46	1.93	10090	14290	14.25	18.30
Pep232	tarea	22253	-	15.27	inf	22079	22253	inf	-15.27
Oni132	tarea	8000	71.87	37.55	6.80	-3051	8906	-65.07	-109.42
Okr132	tarea	18320	58.34	15.14	inf	18146	18320	inf	-73.48
Mel132	tarea	22000	91.60	62.64	inf	21826	22000	inf	-154.24
Pea212	tarea	3155	18.18	19.54	32.24	-405	9278	14.06	-37.82
Sorg233	tarea	63101	17.16	0.24	0.27	62567	63848	-16.89	-17.40
Rbea123	tarea	25000	27.99	5.45	6.90	20367	36314	-21.09	-33.44
Pep233	tarea	18000	43.00	30.84	inf	8169	18000	inf	-73.84
Okr133	tarea	18000	58.34	38.25	inf	-	18000	inf	-96.59
Tom133	tarea	39627	35.37	3.59	0.46	39627	43777	-34.91	-38.96
Pea233	tarea	747	-	0.27	0.24	-	2182	0.24	-0.27

Table 5.27 continued

Activity	Unit	Activity level	Input cost (Cj)	Income Penalty lower	Income Penalty upper	Activity Range Limit lower	Activity Range Limit upper	Cost Range Limit lower	Cost Range Limit upper
Food purchase									
Frice	lbs	1070640	0.28	20.65	0.41	1060606	2021232	0.13	-20.93
Fpast	lbs	223050	0.28	inf	0.29	223050	1963973	0.01	-inf
Fcorn	lbs	669150	0.14	3.86	0.14	619077	4578024	0.0	-4.00
Fbean	lbs	356880	0.38	17.74	1.24	356473	673744	0.86	-18.21
Fplan	lbs	1784400	0.10	inf	0.10	1784400	6799774	0.0	-inf
Fbeef	lbs	24913	0.80	0.50	0.49	203837	60219	-0.31	-1.31
Fchic	lbs	334575	0.68	inf	0.45	334575	369834	-0.20	-inf
Fsard	lbs	384701	1.10	0.13	0.43	384701	393395	-0.67	-1.23
Foil	lbs	107064	1.20	inf	4.13	107064	202123	2.93	-inf
Fsalt	lbs	44610	0.10	0.35	inf	15911	44610	inf	-0.48
Frice2	lbs	1070640	0.28	inf	0.43	1070640	1166978	0.15	-inf
Fpast2	lbs	223050	0.28	inf	0.27	223050	1240920	-0.01	-inf
Fcorn2	lbs	669150	0.14	6.20	0.13	658602	1713410	-0.01	-6.34
Fbean2	lbs	356880	0.38	33.72	1.28	346294	388993	0.90	-34.10
Fplan2	lbs	1784399	0.10	inf	0.10	1784399	6442313	0.0	-inf
Fchic2	lbs	334575	0.65	inf	0.23	334575	526543	-0.42	-inf
Fcodf2	lbs	244539	1.02	0.49	1.01	212579	1216782	-0.01	-1.51
Foil2	lbs	107064	1.20	inf	4.78	107064	116698	3.08	-inf
Frice3	lbs	1070640	0.28	16.11	0.35	1069574	1191434	0.07	-16.39
Fpast3	lbs	223050	0.28	inf	0.18	223050	375544	-0.10	-inf
Fcorn3	lbs	669150	0.14	inf	0.07	669150	762199	-0.07	-inf
Fbean3	lbs	356880	0.38	inf	1.05	356880	397145	0.67	-inf
Fplan3	lbs	1784400	0.10	inf	0.07	1784400	1890892	-0.03	-inf
Fchic3	lbs	334575	0.65	inf	0.32	334575	372263	-0.33	-inf
Farren3	lbs	514631	0.87	0.01	0.01	488618	553030	-0.86	-0.88
Fsard3	lbs	65569	1.10	0.01	0.01	39734	82603	-1.09	-1.11
Foil3	lbs	107064	1.20	inf	3.51	107064	119143	2.31	-inf
Fsalt3	lbs	44610	0.10	0.30	inf	-4520	44610	inf	-0.40

inf = infinite

Table 5.28 presents information on sales, prices and the range over which sales and prices are valid, as well as the penalties associated with departing from the optimum solution. The column activity level shows the amount sold at the regional level in the optimal solution. The column price range limits is an estimate of the sensitivity of the quantity sold to changes in price coefficients (Cj).

Note that selling manioc (syuc) is in the solution at a level of 61,360 quintals. The income penalty column shows that an income penalty of RD$4.33 occurs for each quintal the activity is reduced below the optimum. The same penalty applies until the quantity sold is decreased to 41,571. If sale of manioc is forced to go up beyond the optimum, the penalty is RD$10.81 for each quintal. The same penalty applies up to 90,286 quintals. After this point the penalty probably increases. The quantity of manioc sold has a price of RD$4.67 per quintal. This coefficient can vary from RD$0.34 to RD$15.48 before a change in the level of selling manioc would occur. At a price of RD$0.34 per quintal the level of manioc sold would drop to 41,571 quintals; at a price of RD$15.48 it would jump to 90,286 quintals. This type of information is quite useful for price policy at the regional level. The desired level of marketed output can be achieved by manipulating prices and using them as a tool to stimulate or discourage selected crop production levels and the marketed share of outputs.

Table 5.28: Price Range for the Optimal Solution within which the Optimum Regional Plan Remains Unchanged, Azua, Dominican Republic, 1984.

Activity	Unit	Activity level	Sale price	Income Penalty		Activity Range Limit		Price Range Limit	
				lower	upper	lower	upper	lower	upper
Ssorg	quintal	100000	6.30	0.0	9.31	-131890	100649	6.30	15.61
Srice	quintal	98160	26.00	3.96	inf	0	98160	22.04	inf
Splan	thousand	120868	50.00	5.06	4.93	120868	120868	44.94	54.93
Syuc	quintal	61360	4.67	4.33	10.81	-41571	90286	0.34	15.48
Spep	quintal	216000	10.00	10.00	1.12	-627310	249505	0.0	11.12
Sokr	quintal	219840	12.00	0.24	inf	216000	219840	11.76	inf
Smel	hundred	1157744	4.00	0.08	0.09	1127316	1168325	3.92	4.09
Scorn2	quintal	106455	7.25	0.0	0.0	60578	107196	7.25	7.25
Ssorg2	quintal	100000	6.30	3.45	0.0	97793	200000	2.85	6.30
Srice2	quintal	98160	26.00	0.0	inf	89066	98160	26.00	inf
Sbbea2	quintal	36290	35.00	0.0	1.84	36000	37623	35.00	36.84
Splan2	thousand	120868	50.00	5.06	4.93	120868	120868	44.94	54.93
Spep2	quintal	267036	10.00	1.27	inf	264943	267036	8.73	inf
Soni2	quintal	105600	15.00	13.91	0.52	84000	117589	1.09	15.52
Sokr2	quintal	219840	12.00	1.26	inf	217747	219840	10.74	inf
Smel2	hundred	1188000	4.00	1.16	inf	1178580	1188000	2.84	inf
Scorn3	quintal	32614	7.25	0.0	0.0	31874	78522	7.25	7.25
Ssorg3	quintal	252403	6.30	0.06	0.07	250266	255393	6.24	6.37
Srbea3	quintal	105000	38.05	0.05	5.75	67500	118577	38.00	43.80
Splan3	thousand	120868	50.00	5.06	4.93	120868	120868	44.94	54.93
Spep3	quintal	216000	10.00	2.57	inf	98029	216000	7.43	inf
Sokr3	quintal	216000	12.00	3.19	inf	0	216000	8.81	inf
Stom3	quintal	1534149	2.00	0.09	0.01	1534148	1702847	1.91	2.01

Policy for Increasing Output and Productivity

It is very useful in dealing with agricultural development to have an idea of how farmers respond to government actions when the government contemplates investment in a cash-crop industry. It can be assumed that farmers tend to maximize their welfare in terms of income or consumption. It is possible therefore to predict within a certain error range how small farmers actually will respond to price changes. Insight can be obtained regarding possible magnitudes of output changes in response to price changes by computing a series of net revenue levels for a range of product prices.

In the Dominican Republic, and particularly in the Azua plain, the government already has invested heavily in infrastructure in order to increase agricultural production. However, production has not gone up yet as is demonstrated by the deficit in food production and the growing import of foodstuffs discussed earlier in this study. Public investment in the Azua plain has been one of the largest in the country, but production has not yet been raised to its fullest potential.

It has been argued that small farmers make rational decisions and because of this fact, agricultural development and agricultural land use can be guided in a predictable manner by means of an appropriate agricultural policy. Small farmers also are shown to be responsive to government actions concerning the increase of local availability of new profitable investment opportunities and to be ready to switch from one activity to another which has proven to be more profitable. Comparison of additional costs with additional returns provides the economic framework for decision-making and investment.

Parametric programming allows one to consider the impact of incremental changes in any of the coefficients initially submitted as the basic problem was maximized. This procedure allows insight into the response of the value of the objective function and land use to changes in coefficients such as prices, variable cost and resource availability.

Table 5.29: Comparative Response of Corn and Sorghum to Price Changes, Azua, Dominican Republic, 1984.

Activity Level (tareas)		Net Revenue(*) (RD$)	Quantity Sold (quintal)		Sale Price (RD$)	
corn	sorghum		corn	sorghum	corn	sorghum
70000.00	113000.00	28416851.59	139067.51	452403.43	7.25	6.30
70000.00	113848.19	29005075.94	141321.13	455392.76	8.23	7.28
70000.00	126922.75	30355252.89	141321.14	507691.02	10.50	9.55
70000.00	188240.91	31847293.52	159711.79	752963.68	12.49	11.54
70000.00	226282.01	32572071.16	165086.15	905132.07	13.25	12.30

(*) value of the model's objective function at optimality

As an example of how the model developed in this study can help policy-makers to achieve certain goals, parametric programmining was used in the regional model to simulate the impact of price and capital changes on crop mix and income. Table 5.29 presents information on the comparative response of corn and sorghum levels to price changes. The prices of corn and sorghum were systematically incremented from RD$7.25 to RD$13.25 and RD$6.30 to RD$12.30 respectively in equal amounts, ceteris paribus. The overall corn activity level remained the same, 70,000 tareas, but changes occurred in the technology level and in the type of land used, changing from land type A and B to land type A and from technolgy level 2 to 3. However, the response of the sorghum activity to the price change is very impressive. The amount of land used for growing the crop is increased from 113,000 to 226,282 tareas, more than double the activity level. In addition, changes in the technology level and a switch to better land occur, raising yield per unit of land. As a consequence, net revenue goes up from RD$28,416,852 to RD$32,572,071, an increment of RD$4,155,220. This is an important finding because the Dominican Republic actually is importing some US$30 million in feed grains, mostly sorghum and corn, for the poultry industry.

A parametric run was made using the pararim procedure of the MPSX computer package. This procedure allows simultaneous changes in one or more coefficients in the objective function and of one of the right-hand-side values. In order to get more insight into the stability of the corn activity levels, borrowed capital (at the regional level) was increased from RD$9,993,328 to RD$12,993,928 in fixed intervals. At the same time the selling price of corn was increased from RD$7,25 to RD$19,20 (table 5.30). The activity level of corn remains the same until capital borrowed reaches RD$11,554,428 and the selling price of corn has reached RD$13,49. Only after this point does the corn activity level start to go up significantly in response to the simultaneous increase in the availability of borrowed capital and of the price. However, it should be noted how the shadow price of capital borrowed starts decreasing as more capital is made available.

The information available suggests that an increase in grain output in the short run should be pursued through a policy that stimulates sorghum production instead of corn production. A precondition to the increase of corn output is the development and diffusion of new high yield varieties and the reduction of production costs in order to make corn production more profitable.

Table 5.30: Corn Response to Simultaneous Changes in Price and Capital Availability, Azua, Dominican Republic, 1984.

Net Revenue (RD$)	Borrowed Capital (RD$)	Shadow Price (RD$)	Activity Level (tareas)	Sale Price (RD$)	Quantity Sold (quintal)
28416852.59	9993328.00	0.12	70000.00	7.25	139065.51
28973365.62	10626989.58	0.06	70000.00	9.78	210000.00
29198097.31	10875690.94	0.05	70000.00	10.78	210000.00
29792192.50	11554428.00	0.04	76126.85	13.49	225317.00
30594180.41	12256428.00	0.035	170746.47	16.30	498229.71
31358454.17	12633365.58	0.012	170746.47	17.80	498229.71
32207423.14	12993928.00	0.08	219012.91	19.20	642614.65

The previous discussion is cast in what might be seen as policy recommendations, which should be the aim of most applied research that involves man-land relations. However, the validity of the findings depends on the accuracy of the data used in the programs. As was stated at the beginning of this study, the situation in the Azua plain is changing very fast. Programs always should be revised in the light of changing conditions and the policies adjusted accordingly.

CHAPTER VI
SUMMARY AND CONCLUSION

This chapter summarizes the results of this study and discusses general and specific conclusions. Limitations of this study and a critique of the model are presented. Recommendations and suggestions for future research are outlined.

Summary and Empirical Findings

More and more attention is being paid in LDCs to rural problems of low productivity and malnutrition. A general goal of agricultural planners is to help farmers increase productivity and output as well as strengthen their self reliance. These development efforts have focused on either large-scale farming, small-scale farming or on a combination of both activities. One promising approach is improve the efficiency of resource allocation at the small farm level.

In the Dominican Republic, and particularly in the Azua plain, the three major problems of the peasantry are low output, low income and malnutrition. Because these are related usually to low productivity, solutions often addressed only part of the problem.

The general purpose of this study is to cast light on the means by which productivity can be increased to meet nutritional requirements for the farm-household in the Azua plain.

There are two ways of achieving this objective, a) procuring a better resource allocation and an improved combination of enterprises; and b) introducing new resources to the farm holders. The first way has been addressed by designing and applying a dynamic resource allocation model that takes care of both production and consumption. The second way has been addressed by maximizing net revenue and total output in representative farm-households with a different endowment of resources. In addition, information was aggregated for the Azua plain in order to draw conclusions on policy actions at the regional scale.

The specific objectives of this study are a) to develop a progamming methodology that will help decision-makers evaluate their actions with respect to farmland use and resource allocation in the Azua plain; b) to design and apply a DLP model that can assist in determining the optimal allocation of agricultural land and resources for a set of representative farms in the region, and for the region as a whole; c) to estimate direct and opportunity costs in terms of output or income foregone of alternative agricultural land use; d) to provide a normative land use program that maximizes net revenue and total output, meeting the recommended dietary allowance for the farmers; e) to offer insight into the relationships between family food needs and farm production; and f) to offer information about small farmer behavior that might help in making decisions about credits to small farmers, agrarian reform settlements and price policies.

There is a great deal of disagreement regarding how to analyze economic behavior of farm-households. Perhaps the disagreement has arisen because most theories have tried to generalize a phenomenon which has particular characterstics in each society.

In the Azua plain, the farm-households are not entirely peasant nor are they entirely capitalistic, but they have a heavy orientation towards the market although some family food is produced on the farm.

The nature of the existing agricultural base strongly conditions the development process of agriculture as well as the strategies used to achieve development. Farming in the Azua plain is dominated by farm-households which make all management decisions and control farm labor and capital.

Agricultural transformation and modernization is a process of diffusion of new methods, of combining resources, of new inputs and new techniques for handling crops, including storage, processing and distribution of agricultural input and output.

A farm plan is concerned with identifying the resources available to the individual farmer and prescribing the level of agricultural activities which will give the farmer an optimal allocation of resources in terms of his pre-established goals.

Methodology

A dynamic linear programming model was designed to analyze behavior patterns within three categories of small farmers. Optimum land use, production, consumption and the marketing program were determined indogenously subject to a set of production constraints and nutrient requirements. Then, the units were aggregated in order to draw conclusions at the regional level. Two objective functions were used to maximize net revenue and total output.

The model was applied in the Azua plain, in a region newly irrigated where potential agricultural productivity is regarded as one of the most promising in the country. The model is limited to major short-cycle crops identified by a field survey carried out in the region. The model covers production at the farm and at the regional levels.

The planning period is assumed to be a farm production season of four months. The model repeats the quarterly production cycle recursively to fit the entire agricultural year, which is the planning horizon. A plan for each period emerges from a single optimization.

Results

The major practical concern of this study is to prescribe the land use pattern that yields maximum revenue to the farm-household after meeting certain nutritional household requirements. The results show that even the smallest representative farms can provide the necessary means, either through home production or through generated income, to meet the recommended dietary allowance for the family, and still create a surplus to cover other household expenses or to increase household cash assets. Table 6.1 summarizes the results for the different farm-households and the region.

Table 6.1: Comparison of Objective Function Values for Different Farm-Households and the Region under the Net Revenue and Total Output Maximization Objectives, Azua, Dominican Republic, 1984.

Optimized Objective Function	Representative Farm-Households			Total Irrigated Area, Azua
	25 Tareas	60 Tareas	125 Tareas	
(1) Net Revenue	4436.21	9455.68	15517.78	28416851.59
(2) Total Output	6141.61	10894.13	16681.60	34026642.43

Net revenue and total output reach a maximum by increased farm resource commitment to cash crops. By the same token, a greater reliance on the market as a source for foodstuffs is prescribed. In all farm sizes, black beans emerged as tne most profitable crop, followed by melon and okra. At the regional level, plantain emerged as the leading crop in land use, followed by sorghum and tomatoes.

Land and labor are limiting resources on all farms at some time in the planning horizon. However, land limitation is sharper in the 25 tarea farm-household. When labor is not allowed to be sold off the farm in the 25 tarea farm-households; crop mix becomes more diversified and food purchase becomes more concentrated. The marginal value product of labor drops to zero during most of the planning horizon and the value of net revenue drops from RD$4436.21 to RD$3671.08. Clearly, a means of increasing net revenue in the 25 tarea farm-household is to sell family labor. In larger farm-households, labor is hired in a generous way during most of the planning horizon.

A means of enhancing the family ability to work and at the same time to increase net revenue is the application of a least cost diet. A core of foodstuffs that satisfies the recommended dietary allowance was prescribed for each farm. All nutrient requirements are met, sometimes generously.

Parametric programming was performed at the regional level. Results show that sorghum is very responsive to increases in both selling price and capital availability.

Conclusions

The general conclusion is that accelerated small farm development depends on the set of government policies and programs for the particular region in question. A precondition to achieve regional growth is the extent of government commitment and its capability to act in order to promote small farm development. In a region like the Azua plain, this is even more important, as the government already is involved and only it is in a position to promote small farm development: the government has made huge investments in the infrastructure of the region; it owns most of the irrigated land for which the model was designed; and it already operates a large number of agencies in the area. Nevertheless, the government's effectiveness is very questionable. A reorganization of the agencies operating in the region may be required.

Certain general planning and policy recommendations are suggested in the regional model. Price policy and credit could be used as effective tools to guide resource allocation to desired activities. Because of the unique physical conditions prevailing in the region, orientation of farm-households to the market should be promoted. Grain production (to replace imports) and fruit and vegetable production (for export) should be of major concern to the government.

Given the nature of most of the crops grown in the plain (short-cycle crops), generating a continuous flow of output within the region, agro-industries should be promoted. This to assure a market for agricultural products and to increase locally the value added to agricultural production.

An important aspect of the Azua plain is that, because yields are not close to the maximum obtainable levels, increase in production can be achieved by both increasing yields and by expanding the area under crop production. The choice for policy-makers is clear. In the first case, research and development of new high yield varieties is needed, implying that production increase will take some time. In the second case, expansion of the area cultivated is more immediate, but requires new settlements, immediate high investments and better coordination.

In the area of nutrition, if one considers that the protein content of cereals is ten times greater than that of manioc and five times greater than that of yams, it is clear that an effort should be made to change the prevailing diet from roots and tubers to locally produced cereals such as corn.

Capability and Limitations of the Study

Before adopting the model or implementing the findings, specific limitations regarding the analysis must be recognized. At the farm level, the first stage of a development program must be to assist farm-households to obtain enough resources to achieve a minimum standard of living. The second stage is to provide conditions for growth and/or to generate a surplus that could be transferred out of the agricultural sector. Initially the program should be concerned with extensive development, later the program should shift to intensive development. The second stage should be distinguished by more education, extension and management services. Improved methods of production and generous production credits are fundamental requirements too.

The DLP model could be used to estimate the minimum amount of resources needed for specific income levels. Nevertheless, the model does not provide estimates of the intensive stage. The model does, however, have the following operational advantages: a) it provides a normative solution; b) the method is dynamic and provides a path to growth; c) the method determines the amount of labor that can be drawn out of the farm; d) the method can provide an estimate of normative demand functions for land and other resources; and e) the method can provide an estimate of the normative supply function for commodities over time.

The model presented here has at least three notable limitations: a) it does not consider inter-dependence of farm and non-farm sectors of the economy; b) it assumes that no risk is involved in the various alternatives facing decision-makers; and c) the model aims at a short-run determination of an optimal program.

Finally it should be remembered that the validity of the findings depends on the validity of the data used. Therefore, the program should be revised in terms of changing conditions or when better information is made available.

Suggestions for further Research

It is believed that this research constitutes one of the few studies combining agricultural land use, production, consumption and marketing in a dynamic linear programming framework. Therefore, it is obvious that further methodological refinement is needed. Additional research is needed to define resource limitations and to estimate production, cost and input coefficients.

Future research efforts should consider inter-sectoral relationships as well as expanding the planning horizon. Due to rapidly changing conditions in the region (changes in land use, production costs and prices) estimates of coefficients should not be used to plan over the long run. However, as soon as it is possible to improve estimates of coefficients, the planning horizon should be increased to at least three years.

With these and other refinements, more detailed information for the optimal farm-household organization can be provided for decision-makers and a long-term policy could be implemented in the region.

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APPENDIX A

GINI COEFFICIENTS FOR INCOME DISTRIBUTION IN SELECTED COUNTRIES

Country	Gini Coefficient	Population	Year of Survey
Dominican Rep.			
Urban	0.4711	Per capita household	1976/77
Rural	0.4341	Per capita household	1976/77
Bahamas	0.4674	Households	1970
Chile			
Urban	0.4547	Households	1968
Rural	0.4280	Households	1968
El Salvador	0.4653	Population	1969
Puerto Rico	0.4526	Households	1963
Venezuela			
Urban	0.4413	Households	1962
Rural	0.4520	Households	1962
Brazil	0.5744	Households	1970
Honduras			
Urban	0.5007	Households	1967/68
Rural	0.4861	Households	1967/68
Mexico	0.5827	Households	1969
Costa Rica	0.3757	Per capita household	1971
Panama	0.3609	Households	1962

Source: World Bank, 1980

APPENDIX B

DOMESTIC DEMAND, GROSS DOMESTIC PRODUCT, AND NET EXPORTS, DOMINICAN REPUBLIC, 1960-1978.(*)

Year	Aggregate Demand	Gross Domestic Product	Net Exports
		-Million Pesos-	
1960	697.1	775.6	78.5
1961	679.7	758.2	78.5
1962	874.7	887.2	-12.5
1963	991.5	1945.1	-46.4
1964	1085.4	1008.3	-77.1
1965	894.5	1882.9	-11.6
1966	1068.0	1001.2	-66.8
1967	1080.1	1035.0	-45.1
1968	1101.4	1037.0	-46.3
1969	1227.0	1150.6	-76.4
1970	1381.0	1272.5	-109.1
1971	1471.1	1407.2	-133.8
1972	1631.8	1581.4	-50.4
1973	1800.0	1772.1	-27.9
1974	2369.8	2175.9	-193.9
1975	2490.9	2288.9	-202.0
1976	2546.1	2442.9	-103.2
1977	2679.3	2577.0	-102.3
1978	2707.6	2636.8	-70.8

Source: Banco Central de la Republica Dominicana, 1980; World Bank, 1979

(*) Figures were valued at 1962 prices for the 1960-1973 period, and at 1970 prices for the 1974-1978 period.

APPENDIX C

INDEX NUMBERS OF FOOD AND AGRICULTURAL PRODUCTION, DOMINICAN REPUBLIC, 1966-1979.

Year	Food Production	Agricultural Production	Food Production Per Capita	Agricultural Production Per Capita
		1969-1971 = 100		
1966	81	83	92	94
1967	81	83	90	91
1968	83	84	89	89
1969	93	94	96	97
1970	100	100	100	100
1971	107	104	104	103
1972	109	109	102	102
1973	111	115	101	105
1974	115	117	102	104
1975	109	112	95	97
1976	116	119	98	101
1977	118	123	97	101
1978	127	133	102	107
1979	118	121	92	94

Source: Food and Agriculture Organization, Production Yearbook, 1977-1979 issues.

APPENDIX D

SUMMARY OF CARACTERISTICS, ADEQUATE USE, MANAGEMENT AND AGRONOMIC HANDLING RECOMMENDED FOR SOILS IN THE AZUA REGION, DOMINICAN REPUBLIC.

Management Group	Area			Classification		
	ha	ta	%	Agrologic	For Irrigation Purpose	Taxonomy
1	3,839.4	61,046.5	13.4	IVs,c	4s	Typic Toriorthents
2	10,563.3	167,956.5	36.71	IIIs	$\frac{2s}{C12B2}$ mg	Typic Torrifluvents
3	4.032.0	64,108.8	14.01	Vh,s	5(3s,d)	Ustollic Camborthids
4	1,530.0	24,327.0	5.32	IVh,s	5(3s,d)	Ustollic Camborthids
5	999.0	15,884.1	3.48	IVh,s	$\frac{2s,d}{C22BY}$ w	Ustollic Camborthids
6	5,062.5	80,493.7	17.6	IIIs,e,h	$\frac{2s}{C22CX}$ kf	Typic Torriorthents Typic Torrifluvents
7	625.5	9,945.5	2.18	VIIs,e,c	6s,t	Typic Torriorthents
8	273.6	4,350.2	0.95	VIs.e.c	4f	Typic Torriorthents
9	1,281.42	20,374.6	4.46	VIs,h	6s,d	Aquic Torriorthents Aeric Fluvaquents
10	186.66	2,967.0	0.65	VIII	6st	Miscelaneo Sandy
11	386.1	6,139.0	1.35	VIII	6s.d	Miscelaneo Swampy

APPENDIX D CONTINUED

Management	Recommended Use	Characteristics Limiting the Use	Advised Agronomical Handling
1	Crops with superficial or moderate rooting (cucurbitan and horticltural) Avoid crops sensitive to carbonates	Moderate susceptibility to erosion Low depth Low natural fertility High carbonate content	Conservation practices (contour cropping to limit ero- of top soil) Heavy dosis of fertilizer and micronutrients Irrigation by aspersion and drip Minimum
2	Large range of crops, except those sensitive to carnate (avocado, tobacco, sweet potatoes	Low natural fertility High carbonate content rotation	High dosis offertilizer and micronutrients Adequate crop
3	None	Drainage impeded by very high freatic level	-
4	Crops with moderate and superficial rooting and tolerant to salinity and	Imperfect drainage. freatic level near the surface. Saline and alcaline	Good drainage at farm level Rational use of irrigation water
5	Saline and alcaline tolerant crops	Imperfect drainage. Freatic level that fluctuates at a moderate depth	Good drainage at farm level Rational use of irrigation water
6	Large variety of perennial crops, except those sensitive to the presence of carbonate	irrigation by flooding (regular and frequent) Low natural fertility Moderate susceptibility to erosion Areas with rocks near surface	Adequate crop rotation allowing fallow during months of high flood probability Heavy use of fertilizer with complete formula and micronutrients Irrigation by aspersion and drip
7	Development of forest and wildlife	Steep slopes Severe erosion	-

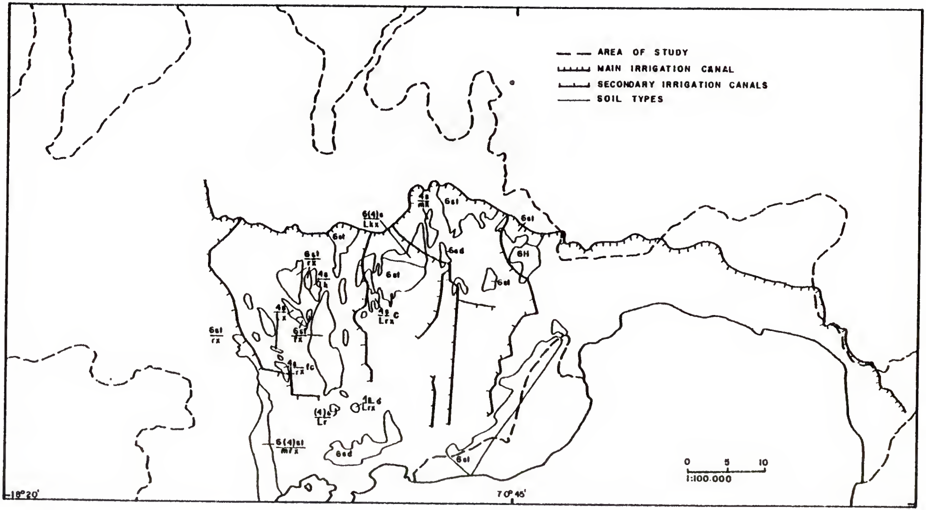
APPENDIX D CONTINUED

Management	Recommended Use	Characteristics Limiting the Use	Advised Agronomical Handling
8	Building-orchard development	Steep slopes Moderate and severe erosion	Special management practices (contour lines,.walls,.etc) Irrigation by aspersion and drip High dosis of fertilizer
9	Not suitable for commercial crops	Poor natural drainage,.high freatic level High salinity and alcalinity	-
10	Wildlife,.recreation and construction material	Dunes	Management directed to stopping dunes from affecting surrounding soils
11	Development of wildlife	Poor drainage (swampy)	-

Source: SEA,.Levantamiento Semidetallado de Suelos de la Llanura de Azua, 1981c.

APPENDIX E

LAND USE AND IRRIGATION CANAL NETWORK, AZUA, DOMINICAN REPUBLIC


AREA OF STUDY
MAIN IRRIGATION CANAL
SECONDARY IRRIGATION CANALS
SOIL TYPES
4s/mll
6sl
6(4)s/Lkx
6sl
6sd
6H
6sl/rx
4s/Lk
6sl
6sl
4s/x
4s/Lrx c
6sl/rx
6sl/rx
4s/rx fc
4s/Lrx 6
(4)s/Lr
6(4)sl/m/x
6sd
6sl
0 5 10
1:100.000
18°20'
70°45'

APPENDIX F

MODEL COEFFICIENTS FOR THE REGIONAL DLP MODEL, AZUA, DOMINICAN REPUBLIC, 1984

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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                                     PAGE    37  -  84/127
              CORN13       CORN21       CORN23       SORG11       SORG12       SORG13       SORG23       RICE11       1....1
NETREV      16.33000-    13.57000-    10.18000-    16.27000-    17.62000-    17.16000-    17.16000-    40.84000-    NETREV
LANDA1       1.00000          .            .        1.00000      1.00000      1.00000          .        1.00000     LANDA1
LANDA2       1.00000          .            .        1.00000      1.00000      1.00000          .        1.00000     LANDA2
LANDA3       1.00000          .            .        1.00000      1.00000      1.00000          .        1.00000     LANDA3
LANDA4       1.00000          .            .        1.00000      1.00000      1.00000          .        1.00000     LANDA4
LANDB1           .        1.00000      1.00000          .            .            .        1.00000          .       LANDB1
LANDB2           .        1.00000      1.00000          .            .            .        1.00000          .       LANDB2
LANDB3           .        1.00000      1.00000          .            .            .        1.00000          .       LANDB3
LANDB4           .        1.00000      1.00000          .            .            .        1.00000          .       LANDB4
COALOT1      1.00000      1.00000      1.00000          .            .            .            .            .       COALOT1
SOALOT1          .            .            .        1.00000      1.00000      1.00000      1.00000          .       SOALOT1
RALOT1           .            .            .            .            .            .            .        1.00000     RALOT1
APRILAB       .78000       .90000       .78000       .18000       .12000       .11000       .15000      2.38000     APRILAB
MAYLAB       1.24000      1.50000       .90000       .48000       .44000       .30000       .28000      1.18000     MAYLAB
JUNLAB        .19000       .70000       .72000       .21000       .18000       .15000       .14000       .80000     JUNLAB
JULLAB       1.44000      1.28000      1.30000      1.28000       .62000       .58000       .58000      2.40000     JULLAB
FINBAL      16.33000     13.57000     10.18000     16.27000     17.16000     17.16000     17.16000     40.84000     FINBAL
OCORN        3.00000-     2.50000-     2.00000-         .            .            .            .            .       OCORN
OSORG            .            .            .        3.30000-     3.88000-     4.00000-     4.00000-         .       OSORG
ORICE            .            .            .            .            .            .            .        3.25000-    ORICE
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..MPSX-VIM7..  REGIONAL  PLANNING  MODEL, AZUA-DR                                                           PAGE    38  -  84/127
           RICL12      RICL13      RICE23      RBEA11      RBEA12      RBEA13      RBEA23      DBEA12        2....1
NETREV    70.88000-   72.68000-   48.98000-   30.84000-   27.99000-   22.67000-   23.28000-   23.3500C-    NETREV
LANDA1     1.00000     1.00000      .          1.00000     1.00000     1.00000      .          1.0C000     LANDA1
LANDA2     1.00000     1.00000      .          1.00000     1.00000     1.00000      .          1.0C000     LANDA2
LANDA3     1.00000     1.00000      .          1.00000     1.00000     1.00000      .          1.0C0C0     LANDA3
LANDA4     1.00000     1.00000      .          1.00000     1.00000     1.00000      .          1.CCCC0     LANDA4
LANDB1      .           .          1.00000      .           .           .          1.00000      .          LANDB1
LANDB2      .           .          1.C0000      .           .           .          1.CC00C      .          LANDB2
LANDB3      .           .          1.00000      .           .           .          1.00000      .          LANDB3
LANDB4      .           .          1.C0000      .           .           .          1.00000      .          LANDB4
RALOT1     1.00000     1.00000     1.00000      .           .           .           .           .          RALOT1
RBALOT1     .           .           .          1.00000     1.00000     1.00000     1.00000      .          RBALOT1
DBALOT1     .           .           .           .           .           .           .          1.00000     DBALOT1
APRILAB    2.22000     2.08000     2.05000     1.01000      .98000      .97000     2.0500C     1.85000     APRILAB
MAYLAB     1.06000     1.06000     1.13000      .96000      .88000      .75000     1.58000      .82CCC     MAYLAB
JUNLAB     2.14000     2.01000     2.07000     1.42000     1.36000     1.28000      .           .47000     JUNLAB
JULLAB      .20000     6.10000     5.18000      .           .           .          1.98000     1.28000     JULLAB
FINBAL    70.88000    72.68000    48.98000    30.84000    27.99000    22.67000    22.28000    23.35000     FINBAL
DRICE      6.30000-    8.18000-    3.C0000-     .           .           .           .           .          DRICE
DRBEA       .           .           .          1.16000-    1.21000-    1.50000-    1.5000C-     .          DRBEA
DBBEA       .           .           .           .           .           .           .          1.27000-    DBBEA
LANDAS     1.00000      .           .           .           .           .           .           .          LANDAS
AUGLAB     3.80000      .           .           .           .           .           .           .          AUGLAB
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                        PAGE   39  -  84/127
            DBEA13       DBEA21       GANO11       GANO13       GANO23       PLAN13       PLAN21       YUC13        3....1
NETREV      18.35000-     8.42000-    13.60000-    26.59000-    20.50000-    14.71000-    14.71000-    18.37000-  NETREV
LANDA1       1.00000      .            1.00000      1.00000      .            1.00000      .            1.00000    LANDA1
LANDA2       1.00000      .            1.00000      1.00000      .            1.00000      .            1.00000    LANDA2
LANDA3       1.00000      .            1.00000      1.00000      .            1.00000      .            1.00000    LANDA3
LANDA4       1.00000      .            1.00000      1.00000      .            1.00000      .            1.00000    LANDA4
LANDB1        .           1.00000      .            .            1.00000      .            1.00000      .          LANDB1
LANDB2        .           1.00000      .            .            1.00000      .            1.00000      .          LANDB2
LANDB3        .           1.00000      .            .            1.00000      .            1.00000      .          LANDB3
LANDB4        .           1.00000      .            .            1.00000      .            1.00000      .          LANDB4
BBALOT1      1.00000      1.00000      .            .            .            .            .            .          BBALOT1
PLALOT1       .            .           .            .            .            1.00000      1.00000      .          PLALOT1
YUALOT1       .            .           .            .            .            .            .            1.00000    YUALOT1
APRILAB      1.60000      1.93000      1.83000      1.52000      1.93000      1.76000      1.58000      1.07000    APRILAB
MAYLAB        .61000       .79000       .68000       .52000       .78000       .31000      3.38000       .62000    MAYLAB
JUNLAB        .38000       .61000       .98000       .75000      1.00000       .20000       .22000       .62000    JUNLAB
JULLAB       1.38000      1.43000      1.20000      1.58000      1.15000       .30000       .30000       .56000    JULLAB
FINBAL      18.35000-     8.42000     13.60000     26.59000     20.50000      7.35000      7.38000     18.37000    FINBAL
DBBEA        2.00000-     1.12000-     .            .            .            .            .            .          DBBEA
OGANO         .            .           3.00000-     3.50000-     3.00000-     .            .            .          OGANO
OPLAN         .            .           .            .            .             .85000-      .85000-     .          OPLAN
OYUC          .            .           .            .            .            .            .            7.25000-   OYUC
LANDA5        .            .           1.00000      1.00000      .            1.00000      .            1.00000    LANDA5
LANDA6        .            .           1.00000      1.00000      .            1.00000      .            1.00000    LANDA6
LANDA7        .            .           1.00000      .            .            1.00000      .            1.00000    LANDA7
LANDA8        .            .           .            .            .            1.00000      .            1.00000    LANDA8
LANDB5        .            .           .            .            .            .            1.00000      .          LANDB5
LANDB6        .            .           .            .            .            .            1.00000      .          LANDB6
LANDB7        .            .           .            .            .            .            1.00000      .          LANDB7
LANDB8        .            .           .            .            .            .            1.00000      .          LANDB8
AUGLAB        .            .           2.00000      1.48000      .             .28000       .20000       .12000    AUGLAB
SEPLAB        .            .           1.80000       .48000      .             .36000       .28000       .06000    SEPLAB
OCTLAB        .            .           .            .            .             .23000       .40000       .24000    OCTLAB
NOVLAB        .            .           .            .            .             .38000       .18000       .59000    NOVLAB
FINBAL2       .            .           .            .            .            3.68000      3.68000      .          FINBAL2
OPLAN2        .            .           .            .            .             .85000-      .85000-     .          OPLAN2
LANDA9        .            .           .            .            .            1.00000      .            1.00000    LANDA9
LANDA10       .            .           .            .            .            1.00000      .            1.00000    LANDA10
LANDA11       .            .           .            .            .            1.00000      .            1.00000    LANDA11
LANDA12       .            .           .            .            .            1.00000      .            .          LANDA12
LANDB9        .            .           .            .            .            .            1.00000      .          LANDB9
LANDB10       .            .           .            .            .            .            1.00000      .          LANDB10
LANDB11       .            .           .            .            .            .            1.00000      .          LANDB11
LANDB12       .            .           .            .            .            .            1.00000      .          LANDB12
JANLAB        .            .           .            .            .             .36000       .36000      1.23000    JANLAB
FEBLAB        .            .           .            .            .             .78000       .78000      .          FEBLAB
MARLAB        .            .           .            .            .            1.20000      1.12000      .          MARLAB
FINBAL3       .            .           .            .            .            3.68000      3.68000      .          FINBAL3
OPLAN3        .            .           .            .            .             .85000-      .85000-     .          OPLAN3
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                               PAGE    40  -  84/127

             YUC23        PEP12        PEP23        ONI12        ONI13        OKR12        OKR13        MEL13        4....1

NETREV      15.73000-    92.19000-    43.00000-    69.00000-    71.87000-    35.27000-    58.24000-    91.60000-    NETREV
LANDA1        .           1.00000       .           1.00000      1.00000      1.00000      1.00000      1.00000     LANDA1
LANDA2        .           1.00000       .           1.00000      1.00000      1.00000      1.00000      1.00000     LANDA2
LANDA3        .           1.00000       .           1.00000      1.00000      1.00000      1.00000      1.00000     LANDA3
LANDA4        .           1.00000       .           1.00000      1.00000      1.00000      1.00000      1.00000     LANDA4
LANDB1       1.00000        .          1.00000        .            .            .            .            .         LANDB1
LANDB2       1.00000        .          1.00000        .            .            .            .            .         LANDB2
LANDB3       1.00000        .          1.00000        .            .            .            .            .         LANDB3
LANDB4       1.00000        .          1.00000        .            .            .            .            .         LANDB4
YUALOT1      1.00000        .            .            .            .            .            .            .         YUALOT1
PEALOT1       .           1.00000      1.00000        .            .            .            .            .         PEALOT1
OKALOT1       .             .            .            .            .          1.00000      1.00000        .         OKALOT1
OKRALOT1      .             .            .            .            .          1.00000      1.00000        .         OKRALOT1
MEALOT1       .             .            .            .            .            .            .          1.00000     MEALOT1
APRILAB      1.02000      2.48000      2.20000      3.69000      3.63000       .38000       .36000       .68000     APRILAB
MAYLAB       1.08000      2.60000      2.50000      3.36000      3.42000      1.32000      1.30000       .86000     MAYLAB
JUNLAB        .20000      1.03000      1.28000      1.72000      1.54000      1.13000      1.18000      1.12000     JUNLAB
JULLAB       1.19000      2.19000      2.08000      3.20000      3.86000      3.17000      4.01000      3.80000     JULLAB
FINBAL      15.73000     92.19000     43.00000     68.00000     71.87000     35.27000     58.24000     91.60000     FINBAL
DYUC         7.67000-       .            .            .            .            .            .            .         DYUC
DPEP          .          17.88000-    12.00000-       .            .            .            .            .         DPEP
DDKR          .             .            .            .            .           6.26000-    12.00000-       .         DDKR
DONI          .             .            .          10.50000-    13.20000-       .            .            .         DONI
DMEL          .             .            .            .            .            .            .          45.00000-    DMEL
LANDA5        .           1.00000      1.00000        .            .            .            .            .         LANDA5
LANDB5       1.00000        .            .            .            .            .            .            .         LANDB5
LANDB6       1.00000        .            .            .            .            .            .            .         LANDB6
LANDB7       1.00000        .            .            .            .            .            .            .         LANDB7
LANDB8       1.00000        .            .            .            .            .            .            .         LANDB8
AUGLAB        .19000      6.14000      5.26000        .            .            .            .            .         AUGLAB
OCTLAB        .29000        .            .            .            .            .            .            .         OCTLAB
NOVLAB        .03000        .            .            .            .            .            .            .         NOVLAB
LANDB9       1.00000        .            .            .            .            .            .            .         LANDB9
LANDB10      1.00000        .            .            .            .            .            .            .         LANDB10
LANDB11      1.00000        .            .            .            .            .            .            .         LANDB11
DECLAB       1.29000        .            .            .            .            .            .            .         DECLAB
JANLAB       1.03000        .            .            .            .            .            .            .         JANLAB
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                                  PAGE    41  -  84/127

                TOM13        TOM23        PEA13        PEA21        PEA23        LHAPRI       LHMAY        LHJUN        S....1

  NETREV      35.37000-    60.85000-    19.10000-    18.18000-    12.25000-     4.00000-     4.00000-     4.00000-    NETREV
  LANDA1       1.00000       .           1.00000       .            .            .            .            .          LANDA1
  LANDA2       1.00000       .           1.00000       .            .            .            .            .          LANDA2
  LANDA3       1.00000       .           1.00000       .            .            .            .            .          LANDA3
  LANDA4       1.00000       .           1.00000       .            .            .            .            .          LANDA4
  LANDB1        .           1.00000       .           1.00000      1.00000       .            .            .          LANDB1
  LANDB2        .           1.00000       .           1.00000      1.00000       .            .            .          LANDB2
  LANDB3        .           1.00000       .           1.00000      1.00000       .            .            .          LANDB3
  LANDB4        .           1.00000       .           1.00000      1.00000       .            .            .          LANDB4
  TOMALOT1     1.00000      1.00000       .            .            .            .            .            .          TOMALOT1
  APRILAB       .46000       .78000      1.18000       .21000       .32000      1.00000-      .            .          APRILAB
  MAYLAB       2.23000      2.18000      1.32000      1.36000      1.28000       .           1.00000-      .          MAYLAB
  JUNLAB       2.78000      2.96000       .91000       .89000       .86000       .            .           1.00000-    JUNLAB
  JULLAB       3.06000      2.99000      3.90000      3.68000      2.98000       .            .            .          JULLAB
  FINBAL      56.37000     60.85000     19.10000     18.18000     12.25000      4.00000      4.00000      4.00000     FINBAL
  DTOM        40.65000-    45.00000-      .            .            .            .            .            .          DTOM
  DPEA          .            .           1.33000-     1.50000-      .97000-      .            .            .          DPEA
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                                      PAGE    42  -  84/127

              LHJUL        LSAPRI       LSMAY        LSJUN        LSJUL        CAPBOR1      CAPTRA1      CCORN        (....1

NETREV       4.00000-     4.00000      4.60000      4.00000      4.00000       .12000-        .            .          NETREV
APRILAB        .          1.00000        .            .            .            .             .            .          APRILAB
MAYLAB         .            .          1.00000        .            .            .             .            .          MAYLAB
JUNLAB         .            .            .          1.00000        .            .             .            .          JUNLAB
JULLAB       1.00000-       .            .            .          1.00000        .             .            .          JULLAB
FINBAL       4.00000      4.00000-     4.00000-     4.00000-     4.00000-     1.00000-      1.00000         .          FINBAL
CAPBOR         .            .            .            .            .          1.00000         .            .          CAPBOR
DCORN          .            .            .            .            .            .             .          1.00000      DCORN
KCAL           .            .            .            .            .            .             .          165100.00    KCAL
PROTE          .            .            .            .            .            .             .          3580.C000    PROTE
FAT            .            .            .            .            .            .             .          540.00000    FAT
CARBY          .            .            .            .            .            .             .          33526.C00    CARBY
CALCI          .            .            .            .            .            .             .          2700.C000    CALCI
IRON           .            .            .            .            .            .             .          500.00000    IRON
VITA           .            .            .            .            .            .             .          20000.000    VITA
THIA           .            .            .            .            .            .             .          64.00000     THIA
RIBO           .            .            .            .            .            .             .          23.0C000     RIBO
NIAC           .            .            .            .            .            .             .          400.C0000    NIAC
VEGPRO         .            .            .            .            .            .             .          3580.CC00    VEGPRO
FCALOT1        .            .            .            .            .            .             .          1.00000      FCALOT1
FINBAL2        .            .            .            .            .            .           1.00000-       .          FINBAL2
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..MPSX-V1M7..  REGIONAL PLANNING MODEL, AZUA-DR                                                   PAGE    43  -  84/127
            CHICE       CHUEA       CHUEA       CGAND       CPLAN       CYUC        CMEL        CPEAN       7....1

DRICE       1.00000       .           .           .           .           .           .           .         DRICE
DRBEA         .         1.00000       .           .           .           .           .           .         DRBEA
DBBEA         .           .         1.00000       .           .           .           .           .         DBBEA
DGAND         .           .           .         1.00000       .           .           .           .         DGAND
DPLAN         .           .           .           .         1.00000       .           .           .         DPLAN
DYUC          .           .           .           .           .         1.00000       .           .         DYUC
DMEL          .           .           .           .           .           .         1.00000       .         DMEL
DPEA          .           .           .           .           .           .           .         1.00000     DPEA
KCAL        164700.00   152900.00   154700.00   152900.00   413000.00   49300.000   6800.0000   255000.00   KCAL
PROTE       3040.0000   9900.0000   10903.000   8700.0000   3800.0000   410.00000   160.00000   11750.000   PROTE
FAT         180.00000   730.00000   540.00000   680.00000   300.00000   100.00000   20.00000    21550.000   FAT
CARBY       30470.000   25880.000   27530.000   20710.000   110500.00     .         1700.0000   8440.0000   CARBY
CALCI       10900.000   39000.000   34900.000   62100.000   25000.000     .         3200.0000   26800.000   CALCI
IRON        360.00000   3450.0000   3270.0000   2270.0000   390000.00   240.00000   90.00000    910.00000   IRON
VITA          .         500.00000   2500.0000   2500.0000   220.00000     .         77000.000     .         VITA
THIA        32.00000    245.00000   395.00000   327.00000   130.00000   20.00000      .         449.00000   THIA
RIBO        12.00000    86.00000    104.00000   77.00000    1600.0000   10.00000      .         59.00000    RIBO
NIAC        720.00000   950.00000   846.00000   1180.0000   88000.000   200.00000   1400.0000   7170.0000   NIAC
VITC          .         1400.0000   1400.0000     .           .         12200.000   7400.0000     .         VITC
VEGPRO      3040.0000   9900.0000   10903.000   8710.0000   3800.0000   410.00000     .         117.90000   VEGPRO
RBBALI      1.00000-    3.00000     3.00000       .           .           .           .           .         RBBALI
RUBALI      1.00000-      .           .           .           .           .           .           .         RUBALI
FRALOTI     1.00000       .           .           .           .           .           .           .         FRALOTI
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR
                                                                                        PAGE    44  -  84/127
            SSURG        SRICE        SCORN        SRBEA        SBBEA        SGAND        SPLAN        SYUC          8....1
NETREV      6.30000      26.00000     7.25000      38.00000     35.00000     18.00000     50.00000     4.67000      NETREV
CHSCORN      .             .          2.00000        .            .            .            .            .          CHSCORN
DCORN        .             .          1.00000        .            .            .            .            .          DCORN
DSDRG       1.00000        .             .           .            .            .            .            .          DSDRG
DRICE        .            1.00000        .           .            .            .            .            .          DRICE
DRBEA        .             .             .          1.00000       .            .            .            .          DRBEA
DBBEA        .             .             .           .           1.00000       .            .            .          DBBEA
DGAND        .             .             .           .            .           1.00000       .            .          DGAND
DPLAN        .             .             .           .            .            .           1.00000       .          DPLAN
DYUC         .             .             .           .            .            .            .           1.00000     DYUC
FINBAL2     6.30000-     26.00000-    7.25000-     38.00000-    35.00000-    18.00000-    50.00000-    4.67000-     FINBAL2
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                              PAGE    45  -  84/127

               SPEP         SDKR         SMEL         SPEA         STCORN       STSORG       STRICE       STRBEAN      9....1

NETREV         10.00000     12.00000      4.00000     15.00000       .            .            .            .          NETREV
DCORN            .            .            .            .           1.00000       .            .            .          DCORN
DSORG            .            .            .            .            .           1.00000       .            .          DSORG
DRICE            .            .            .            .            .            .           1.00000       .          DRICE
DRBEA            .            .            .            .            .            .            .           1.00000    DRBEA
DPEP            1.00000       .            .            .            .            .            .            .          DPEP
DDKR             .           1.00000       .            .            .            .            .            .          DDKR
DMEL             .            .           1.00000       .            .            .            .            .          DMEL
DPEA             .            .            .           1.00000       .            .            .            .          DPEA
FINBAL2        10.00000-    12.00000-     4.00000-    15.00000-      .            .            .            .          FINBAL2
DCORN2           .            .            .            .           1.00000-      .            .            .          DCORN2
DSORG2           .            .            .            .            .           1.00000-      .            .          DSORG2
DRBEA2           .            .            .            .            .            .            .           1.00000-   DRBEA2
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                              PAGE   46  -  84/127
            STBBEAN       STGAND        FRICE         FPAST         FCORN         FBREAD        FSPOT         FPCT          10....1
NETREV         .             .             .28000-       .28000-       .14000-       .36000-       .10000-       .17000-   NETREV
FINBAL         .             .             .28000        .32000        .14000        .36000        .10000        .17000    FINBAL
DBBEA         1.00000        .             .             .             .             .             .             .         DBBEA
DGAND          .            1.00000        .             .             .             .             .             .         DGAND
KCAL           .             .         1647.0000     1674.0000     1651.0000     1220.0000      440.00000     316.00000    KCAL
PROTE          .             .           30.40000      56.70000      35.58000      39.50000       4.90000       7.70000    PROTE
FAT            .             .            1.80000       5.54000       5.40000      14.50000       1.50000        .40000    FAT
CARBY          .             .          364.70000     341.10000     355.60000     228.60000     103.20000      73.30000    CARBY
CALCI          .             .          109.00000     122.00000      27.00000       3.18000     128.00000      31.00000    CALCI
IRON           .             .            3.60000       5.90000       5.00000       3.20000       3.00000       2.70000    IRON
VITA           .             .             .             .          200.00000        .           40.00000        .         VITA
THIA           .             .             .30000        .40000        .64000        .31000        .38000        .35000    THIA
RIBO           .             .             .10000        .30000        .23000        .36000        .19000        .12000    RIBO
NIAC           .             .             .70000        .80000       4.00000       5.00000       2.30000       5.40000    NIAC
VITC           .             .             .             .             .             .           87.00000      39.00000    VITC
VEGPRO         .             .           30.40000      56.70000      35.80000      39.50000       4.90000       7.70000    VEGPRO
RBBALI         .             .            1.00000-       .             .             .             .             .         RBBALI
RUBALI         .             .            1.00000-       .             .             .             .             .         RUBALI
FRALOTI        .             .            1.00000        .             .             .             .             .         FRALOTI
FPALOTI        .             .             .            1.00000        .             .             .             .         FPALOTI
FCALOTI        .             .             .             .            1.00000        .             .             .         FCALOTI
DBBEA2        1.00000-       .             .             .             .             .             .             .         DBBEA2
DGAND2         .            1.00000-       .             .             .             .             .             .         DGAND2
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..MPSX-VIP7..  REGIONAL PLANNING MODEL, AZUA-DR                                                     PAGE    47  -  84/127
            FYUC          FSUG          FBEAN         FGARL         FONI          FBAN          FPLAN         FBEEF        II....I

NETREV        .08000-       .18000-       .38000-      1.66000-       .30000-       .09000-       .10000-       .80000-   NETREV
FINBAL        .17000        .18000        .38000       1.46000        .30000        .10000        .10000        .80000    FINBAL
KCAL       493.00000     1746.0000     1529.0000     549.00000     169.00000     359.00000     413.00000     1021.0000    KCAL
PROTE        4.10000         .           99.00000     22.60000       5.90000       4.10000       3.80000      66.70000    PROTE
FAT          1.00000         .            7.30000       .90000        .80000        .60000        .30000      80.00000    FAT
CARBY      119.40000      451.30000     258.80000     129.00000      38.00000      83.30000     110.50000        .         CARBY
CALCI      112.00000         .          390.00000     162.00000     135.00000      23.00000      25.00000      38.00000    CALCI
IRON         2.40000         .           34.50000       6.00000       2.10000       2.50000       2.50000       8.00000    IRON
VITA           .             .            5.00000       5.00000       5.00000       2.75000     390.00000      40.00000    VITA
THIA          .20000         .            2.45000        .90000        .13000        .12000        .22000        .23000    THIA
RIBO          .10000         .             .86000        .34000        .17000        .06000        .13000      40.00000    RIBO
NIAC         2.00000         .            9.50000       2.60000        .80000       1.70000       1.60000      14.10000    NIAC
VITC       122.00000         .           14.00000      38.00000      30.00000      90.00000      88.00000        .         VITC
ANPRO          .             .              .             .             .             .             .          66.70000    ANPRO
VEGPRO       4.10000         .           99.00000      22.60000       5.90000       4.10000       3.80000        .         VEGPRO
RBBALI         .             .            3.00000        .             .             .             .             .         RBFALI
FPLALOTI       .             .              .             .             .             .           1.00000        .         FPLALCTI
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                                  PAGE   48  -  84/127

            FPORK        FCHIC        FEGG         FARHEN       FCLDF        FSAND        FMILK        FDMILK       12....I

NETREV       .73000-      .65000-     3.54000-      .87000-     1.02000-     1.10000-      .66000-     2.58000-     NETREV
FINBAL       .73000       .65000       .54000       .87000      1.02000      1.10000       .66000      2.58000      FINBAL
KCAL      187.70000    524.00000    658.00000    293.00000    1018.0300    1411.0000    295.00000    2295.0000      KCAL
PROTE      36.30000     56.10000     52.10000     60.90000    153.10000     93.40000     15.90000    117.90000      PROTE
FAT       185.20000     31.50000     46.40000      3.70000      5.80000    110.70000     22.70000    136.10000      FAT
CARBY        .20000         .         3.60000         .            .         2.70000     22.70000    154.00000      CARBY
CALCI      21.00000     43.00000    218.00000    1556.0000    193.00000    1606.0000    540.00000    3892.0000      CALCI
IRON        5.30000      4.60000      9.30000      2.40000     11.60000     15.90000       .50000      3.20000      IRON
VITA         .30000     60.00000    505.00000        .            .        245.00000    180.00000    1635.0000      VITA
THIA       11.77000       .25000       .42000       .03000       .31000       .10000       .18000      1.13000      THIA
RIBO         .42000       .49000    120.00000       .27000      2.31000       .76000       .82000      5.67000      RIBO
NIAC        9.40000     29.70000       .20000     12.60000     11.60000     20.10000       .50000     18.00000      NIAC
VITC           .            .            .            .          .60000         .            .            .         VITC
ANPRO      36.30000     56.10000     52.10000     60.90000    153.10000     93.00000     15.90000    117.90000      ANPRO
CMILK          .            .            .            .            .            .         1.00000      1.00000      CMILK
FCHALOTI .     .         1.00000         .            .            .            .            .            .         FCHALOTI
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                              PAGE    49  -  84/127
              FOIL         FSALT        FTOMP        FCOFF        FCHFE        FHUT         FCOC         CORN132      13....1

NETREV        1.20000-      .10000-     1.10000-     1.40000-     2.75000-     2.25000-     1.25000-    16.32000-     NETREV
FINDAL        1.20000       .10000      1.10000      1.40000      2.75000      2.25000      1.25000       .           FINDAL
KCAL       4010.0000         .        372.00000    254.00000   1175.0000      34.48000   2395.0000        .           KCAL
PROTE           .            .         15.40000     36.30000    113.40000      2.70000     20.00000       .           PROTE
FAT         543.00000        .          1.80000       .         113.40000    367.40000    159.20000       .           FAT
CARBY           .            .         84.40000     27.20000      9.10000      1.80000   2626.00000       .           CARBY
CALCI           .         1148.0000   122.00000    136.00000   3175.0000      68.00000    426.00000       .           CALCI
IRON            .            .         15.90000      4.50000      4.50000       .           6.40000       .           IRON
VITA            .            .       1500.0000        .        1905.0000    4355.0000      60.00000       .           VITA
THIA            .            .           .88000       .            .05000       .            .11000       .           THIA
RIBO            .            .           .54000      .05000      2.04000       .            .64000       .           RIBO
NIAC            .            .         14.20000    122.50000      .50000       .           1.50000       .           NIAC
VITC            .            .        221.00000       .            .            .            .            .           VITC
ANPRO           .            .            .           .         113.40000      2.70000       .            .           ANPRO
VEGPRO          .            .          1.80000     36.30000       .            .          20.00000       .           VEGPRO
ROBALI       10.00000        .            .           .            .            .            .            .           ROBALI
FSALOTI         .         1.00000         .           .            .            .            .            .           FSALOTI
LANDA5          .            .            .           .            .            .            .          1.00000      LANDA5
LANDA6          .            .            .           .            .            .            .          1.00000      LANDA6
LANDA7          .            .            .           .            .            .            .          1.00000      LANDA7
LANDA8          .            .            .           .            .            .            .          1.00000      LANDA8
CUALOT2         .            .            .           .            .            .            .          1.00000      CUALOT2
AUGLAB          .            .            .           .            .            .            .           .75000      AUGLAB
SEPLAB          .            .            .           .            .            .            .          1.44000      SEPLAB
OCTLAB          .            .            .           .            .            .            .           .75000      OCTLAB
NOVLAB          .            .            .           .            .            .            .          1.18000      NOVLAB
FINBAL2         .            .            .           .            .            .            .         16.32000      FINBAL2
DCORN2          .            .            .           .            .            .            .          3.00000-     DCORN2
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR                                                      PAGE    50  -  84/127
             CURN212       CORN232       SORG112       SORG122       SORG132       SORG232       RICE112       RICE122      14.....1

NETREV      13.57000-     10.18000-     16.27000-     17.62000-     17.16000-     17.16000-     40.84000-     70.88000-     NETREV
LANDA5        .             .            1.00000       1.00000       1.00000        .            1.00000       1.00000      LANDA5
LANDA6        .             .            1.00000       1.00000       1.00000        .            1.00000       1.00000      LANDA6
LANDA7        .             .            1.00000       1.00000       1.00000        .            1.00000       1.00000      LANDA7
LANDA8        .             .            1.00000       1.00000       1.00000        .            1.00000       1.00000      LANDA8
LANDB5       1.00000       1.00000        .             .             .            1.00000        .             .           LANDB5
LANDB6       1.00000       1.00000        .             .             .            1.00000        .             .           LANDB6
LANDB7       1.00000       1.00000        .             .             .            1.00000        .             .           LANDB7
LANDB8       1.00000       1.00000        .             .             .            1.00000        .             .           LANDB8
COALOT2      1.00000       1.00000        .             .             .             .             .             .           COALOT2
SOALOT2       .             .            1.00000       1.00000       1.00000       1.00000        .             .           SOALOT2
RALOT2        .             .             .             .             .             .            1.00000       1.00000      RALOT2
AUGLAB        .70000        .80000        .21000        .18000        .14000        .17000       3.13000       1.45000      AUGLAB
SEPLAB       1.50000       1.30000        .48000        .48000        .45000        .47000       3.30000       2.03000      SEPLAB
OCTLAB       1.08000        .60000        .18000        .53000        .48000        .51000       2.31000        .16000      OCTLAB
NOVLAB       1.88000       1.17000        .48000        .70000        .50000        .52000       1.77000       1.46000      NOVLAB
FINBAL2     13.57000      10.78000      16.29000      17.62000      17.16000      17.16000      40.84000      70.88000      FINBAL2
DCORN2       2.50000-      2.00000-       .             .             .             .             .             .           DCORN2
DSORG2        .             .            3.38000-      3.88000-      4.00000-      4.00000-       .             .           DSORG2
DRICE2        .             .             .             .             .             .            3.25000-      6.30000-     DRICE2
LANDA9        .             .             .             .             .             .            1.00000       1.00000      LANDA9
LANDA10       .             .             .             .             .             .            1.00000      10.00000      LANDA10
DECLAB        .             .             .             .             .             .             .11000        .11000      DECLAB
JANLAB        .             .             .             .             .             .            3.18000       3.00000      JANLAB
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                              PAGE    51  -  84/127
             RICE132      RICE232      RBLA112      RBLA122      RBEA132      RBEA232      BBEA122      BBEA132      15....I
NETREV       72.68000-    48.98000-    30.84000-    27.99000-    22.67000-    23.28000-    23.35000-    18.35000-    NETREV
LANDA5        1.00000         .         1.00000      1.00000      1.00000         .         1.00000      1.00000     LANDA5
LANDA6        1.00000         .         1.00000      1.00000      1.00000         .         1.00000      1.00000     LANDA6
LANDA7        1.00000         .         1.00000      1.00000      1.00000         .         1.00000      1.00000     LANDA7
LANDA8        1.00000         .            .         1.00000      1.00000         .         1.00000      1.00000     LANDA8
LANDB5           .         1.00000         .            .            .         1.00000         .            .        LANDB5
LANDB6           .         1.00000         .            .            .         1.00000         .            .        LANDB6
LANDB7           .         1.00000         .            .            .         1.00000         .            .        LANDB7
LANDB8           .         1.00000         .            .            .         1.00000         .            .        LANDB8
RALOT2        1.00000      1.00000         .            .            .            .            .            .        RALOT2
RBALOT2          .            .         1.00000      1.00000      1.00000      1.00000         .            .        RBALOT2
BBALOT2          .            .            .            .            .            .         1.00000      1.00000     BBALOT2
AUGLAB        1.54000      1.48000      1.40000      1.27000      1.47000      2.84000      1.47000       .20000     AUGLAB
SEPLAB        1.60000      1.53000       .95000       .94000       .90000       .99000       .90000       .10000     SEPLAB
OCTLAB        1.35000      1.28000      1.95000      1.72000       .51000      2.04000       .51000       .40000     OCTLAB
NOVLAB         .56000       .48000         .            .         1.36000         .         1.36000      1.60000     NOVLAB
FINBAL2      72.68000     48.98000     30.82000     27.99000     22.67000     23.28000     23.25000     18.35000     FINBAL2
DRICE2        8.18000-     3.00000-        .            .            .            .            .            .        DRICE2
DRBEA2           .            .         1.16000-     1.21000-     1.50000-     1.50000-        .            .        DRBEA2
DBBEA2           .            .            .            .            .            .         1.27000-     2.00000-    DBBEA2
LANDA9        1.00000         .            .            .            .            .            .            .        LANDA9
LANDB9           .         1.00000         .            .            .            .            .            .        LANDB9
DECLAB        5.50000      4.59000         .            .            .            .            .            .        DECLAB
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                                      PAGE    52  -  84/127

              BBEA212      BBEA232      GAND112      GAND132      GAND232      PEP122       PEP232       ONI132       16....1

NETREV         8.42000-    18.35000-    13.60000-    26.59000-    20.50000-    54.14000-        .        71.87000-   NETREV
LANDA5            .            .         1.00000      1.00000         .         1.00000         .         1.00000    LANDA5
LANDA6            .            .         1.00000      1.00000         .         1.00000         .         1.00000    LANDA6
LANDA7            .            .         1.00000      1.00000         .         1.00000         .         1.00000    LANDA7
LANDA8            .            .         1.00000      1.00000         .         1.00000         .         1.00000    LANDA8
LANDB5         1.00000      1.00000         .            .         1.00000         .            .            .        LANDB5
LANDB6         1.00000      1.00000         .            .         1.00000         .            .            .        LANDB6
LANDB7         1.00000      1.00000         .            .         1.00000         .            .            .        LANDB7
LANDB8         1.00000      1.00000         .            .         1.00000         .         1.00000         .        LANDB8
BBALOT2        1.00000      1.00000         .            .            .            .            .            .        BBALOT2
PEALOT2           .            .            .            .            .         1.00000      1.00000         .        PEALOT2
PEPALOT2          .            .            .            .            .         1.00000      1.00000         .        PEPALOT2
ONALOT2           .            .            .            .            .            .            .         1.00000    ONALOT2
ONIALOT2          .            .            .            .            .            .            .         1.00000    ONIALOT2
AUGLAB         1.39000      1.24000      2.00000      1.48000      2.06000      2.40000      2.53000      1.93000    AUGLAB
SEPLAB          .70000      1.95000      1.80000       .48000       .47000      3.80000      2.78000      5.36000    SEPLAB
OCTLAB          .48000       .10000       .24000       .74000      1.71000      1.67000      1.80000      4.04000    OCTLAB
NOVLAB         1.85000      1.15000       .59000       .36000         .         8.20000      7.20000      4.56000    NOVLAB
FINBAL2       25.16000     19.35000     13.98000     26.59000     20.50000     52.19000     43.00000     71.87000    FINBAL2
DBBEA2         1.12000-     2.00000-        .            .            .            .            .            .        DBBEA2
DGAND2            .            .         3.00000-     3.50000-     3.00000-        .            .            .        DGAND2
DPEP2             .            .            .            .            .         9.76000-    12.00000-        .        DPEP2
DONI2             .            .            .            .            .            .            .        13.20000-   DONI2
LANDA9            .            .         1.00000      1.00000         .            .         1.00000      1.00000    LANDA9
LANDA10           .            .         1.00000      1.00000         .            .            .            .        LANDA10
LANDB9            .            .            .            .         1.00000         .            .            .        LANDB9
DECLAB            .            .            .            .          .60000         .            .         5.37000    DECLAB
JANLAB            .            .         1.82000      1.97000      1.72000         .            .            .        JANLAB
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..MPSX-VIM7..  REGIONAL PLANNING MCDEL, AZUA-DR                                                         PAGE    53  -  84/127

            UNI122       UKR122       OKR132       MEL132       PEA132       PEA212       PEA232       LPAUG        17.....1

NETREV      68.00000-    35.27000-    58.34000-    91.60000-    19.10000-    18.18000-    12.25000-    4.0000C-     NETREV
LANDA5       1.00000      1.00000      1.00000      1.00000      1.00000       .            .            .           LANDA5
LANDA6       1.00000      1.00000      1.C0000      1.00000      1.C0000       .            .            .           LANDA6
LANDA7       1.00000      1.00000      1.00000      1.00000      1.C0000       .            .            .           LANDA7
LANDA8       1.00000      1.0000C      1.00000      1.00000      1.00000       .            .            .           LANDA8
LANDB5        .            .            .            .            .           1.00000      1.00000       .           LANDB5
LANDB6        .            .            .            .            .           1.00000      1.00000       .           LANDB6
LANDB7        .            .            .            .            .           1.00000      1.00000       .           LANDB7
LANDB8        .            .            .            .            .           1.00000      1.00000       .           LANDB8
UNALOT2      1.00000       .            .            .            .            .            .            .           ONALOT2
ONIALOT2     1.00000       .            .            .            .            .            .            .           UNIALCT2
OKALCT2       .           1.00000      1.0000C       .            .            .            .            .           OKALOT2
OKRALOT2      .           1.00000      1.00000       .            .            .            .            .           OKRALUT2
MEALOT2       .            .            .           1.00000       .            .            .            .           MEALOT2
AUGLAB       2.10000      2.48000      2.20C00       .86000       .73000       .11000       .82000      1.0000C-     AUGLAB
SEPLAB       4.06000       .80000       .81000       .78000       .14000       .12000       .28000       .           SEPLAB
OCTLAB       3.88000      1.80000      1.68000      1.18000      1.98000       .10000      1.850CC       .           OCTLAB
NOVLAB       5.28000      3.20000      4.1000C      3.72000       .            .07000       .            .           NOVLAB
FINBAL2     82.19000     35.27000     38.2400C     91.60000     19.10000     18.18000     12.25000      4.00000      FINBAL2
DONI2       10.50000-      .            .            .            .            .            .            .           DONI2
DUKR2         .           6.26000-    12.00000-      .            .            .            .            .           DOKR2
DMEL2         .            .            .          54.00000-      .            .            .            .           DMEL2
DPEA2         .            .            .            .           1.33000-     1.50000-      .9700C-      .           DPEA2
LANDA9       1.00000       .            .            .            .            .            .            .           LANDA9
DECLAB       5.37000       .            .            .            .            .            .            .           DECLAB
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                                    PAGE    54  -  84/127

            LHSEP       LHOCT       LHNOV       LSAUG       LSSEP       LSOCT       LSNOV       CAPTHA2      IP....I

NETREV     4.00000-    4.00000-    4.00000-    4.00000     4.00000     4.00000     4.00000        .         NETREV
AUGLAB        .           .           .        1.00000        .           .           .           .         AUGLAB
SEPLAB     1.00000-       .           .           .        1.00000        .           .           .         SEPLAB
OCTLAB        .        1.00000-       .           .           .        1.00000        .           .         OCTLAB
NOVLAB        .           .        1.00000-       .           .           .        1.00000        .         NOVLAB
FINBAL2    4.00000     4.00000     4.00000     4.00000-    4.00000-    4.00000-    4.00000-    1.00000      FINBAL2
FINBAL3       .           .           .           .           .           .           .        1.00000-     FINBAL3
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..MPSX-VIP7..  REGIONAL  PLANNING  MODEL, AZUA-DR                                              PAGE    55  -  84/127

              CCURN2       CRICE2       CRBEA2       CBBEA2       CGAND2       CPLAN2       CONI2        CPEAN2       19....1

DCURN2         1.00000       .            .            .            .            .            .            .         DCURN2
DRICE2          .           1.00000       .            .            .            .            .            .         DRICE2
DRBEA2          .            .           1.00000       .            .            .            .            .         DRBEA2
DBBEA2          .            .            .           1.00000       .            .            .            .         DBBEA2
DPLAN2          .            .            .            .            .           1.00000       .            .         DPLAN2
DONI2           .            .            .            .            .            .           1.00000       .         DONI2
DPEA2           .            .            .            .            .            .            .           1.00000    DPEA2
KCAL2        165100.00    164700.00    152900.00    154700.00    152900.00    413000.00    16900.000    255000.00    KCAL2
PROTE2       3580.0000    3040.0000    9900.0000    10903.000    8700.0000    3800.0000    590.00000    11790.000    PROTE2
FAT2         540.00000    180.00000    730.00000    540.00000     .           300.00000    80.00000     21550.000    FAT2
CARBY2       33526.000    36470.000    25880.000    27530.000    28710.000    110500.00    3800.0000    8440.0000    CARBY2
CALCI2       2700.0000    10900.000    39000.000    34900.000    62100.000    25000.000    13500.000    26800.000    CALCI2
IRON2        500.00000    360.00000    3450.0000    3270.0000    2270.0000    390000.00    210.00000    910.00000    IRON2
VITA2        20000.000     .           500.00000    2500.0000    2500.0000    220.00000    500.00000     .           VITA2
THIA2         64.00000    32.00000     245.00000    395.00000    327.00000    130.00000    13.00000     449.00000    THIA2
RIBO2         23.00000    12.00000      86.00000    104.00000     77.00000    1600.0000    17.00000      59.00000    RIBO2
NIAC2        400.00000    720.00000    550.00000    846.00000    1180.0000    88000.000    80.00000     7170.0000    NIAC2
VITC2           .            .         1400.0000    1400.0000     .            .           3800.0000     .           VITC2
VEGPRO2      3580.0000    3040.0000    9900.0000    10903.000    8710.0000    3800.0000    590.00000    11790.000    VEGPRO2
RBBAL2          .          1.00000-     3.00000      3.00000      .            .            .            .           RBBAL2
RDBAL2          .          1.00000-      .            .            .            .            .            .           RDBAL2
FCALDT2        1.00000       .            .            .            .            .            .            .         FCALDT2
FAT3            .            .            .            .          680.00000      .            .            .         FAT3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-JR                                              PAGE    56  -  84/127

              SCORN2        SSORG2        SRICE2        SRBEA2        SBBEA2        SGAND2        SPLAN2        SPEP2          20....1

NETREV        7.25000       6.30000       26.00000      38.00000      35.00000      18.00000      50.00000      10.00000       NETREV
CHSCGRN       2.00000        .             .             .             .             .             .             .             CHSCGRN
DCORN2        1.00000        .             .             .             .             .             .             .             DCORN2
DSORG2         .            1.00000        .             .             .             .             .             .             DSORG2
DRICE2         .             .            1.00000        .             .             .             .             .             DRICE2
DRBEA2         .             .             .            1.00000        .             .             .             .             DRBEA2
DBBEA2         .             .             .             .            1.00000        .             .             .             DBBEA2
DGAND2         .             .             .             .             .            1.00000        .             .             DGAND2
DPLAN2         .             .             .             .             .             .            1.00000        .             DPLAN2
DPEP2          .             .             .             .             .             .             .            1.00000        DPEP2
FINBAL3       7.25000-      6.30000-      26.00000-     38.00000-     35.00000-     18.00000-     50.00000-     10.00000-      FINBAL3
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                                              PAGE    57  -  84/127
             SUNI2        SOKR2        SMEL2        SPEA2        STCORN2      STRICE2      STRBEAN2     STBBEAN2     21....1
NETREV       15.00000     12.00000      4.00000     15.00000      .            .            .            .           NETREV
DCURN2         .            .            .            .           1.00000      .            .            .           DCORN2
DRICE2         .            .            .            .            .           1.00000      .            .           DRICE2
DRBEA2         .            .            .            .            .            .           1.00000      .           DRBEA2
DBBEA2         .            .            .            .            .            .            .           1.00000     DBBEA2
DUNI2         1.00000       .            .            .            .            .            .            .           DUNI2
DOKR2          .           1.00000       .            .            .            .            .            .           DOKR2
DMEL2          .            .           1.00000       .            .            .            .            .           DMEL2
DPEA2          .            .            .           1.00000       .            .            .            .           DPEA2
FINBAL3      15.00000-    12.00000-     4.00000-    15.00000-      .            .            .            .           FINBAL3
DCURN3         .            .            .            .           1.00000-      .            .            .           DCORN3
DRICE3         .            .            .            .            .           1.00000-      .            .           DRICE3
DRBEA3         .            .            .            .            .            .           1.00000-      .           DRBEA3
DBBEA3         .            .            .            .            .            .            .           1.00000-     DBBEA3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                                        PAGE    59  -  84/127

              FSUG2       FBEAN2      FGARL2      FONI2       FBAN2       FPLAN2      FBEEF2      FPORK2      23....1

NETREV         .18000-     .38000-    1.66000-     .30000-     .09000-     .10000-     .80000-     .72000-   NETREV
FINBAL2        .18000      .38000     1.46000      .30000      .10000      .10000      .80000      .70000    FINBAL2
KCAL2       1746.0000   1529.0000   549.00000   169.00000   359.00000   413.00000   1021.0000   187.70000    KCAL2
PROTE2           .       99.00000    22.60000     5.90000     4.10000     3.80000    66.70000    36.30000    PROTE2
FAT2             .        7.30000      .90000      .80000      .60000      .30000    80.00000   185.20000    FAT2
CARBY2       451.30000  258.80000   129.00000    38.00000    83.30000   110.50000        .         .20000    CARBY2
CALCI2           .      390.00000   162.00000   135.00000    23.00000    25.00000    38.00000    21.00000    CALCI2
IRON2            .       34.50000     6.00000     2.10000     2.50000     2.50000     8.00000     5.30000    IRON2
VITA2            .        5.00000     5.00000     5.00000     2.75000   390.00000    40.00000      .30000    VITA2
THIA2            .        2.45000      .50000      .13000      .12000      .22000      .23000    11.77000    THIA2
RIBO2            .         .86000      .34000      .17000      .06000      .13000    40.00000      .42000    RIBO2
NIAC2            .        9.50000     2.60000      .80000     1.70000     1.60000    14.10000     9.40000    NIAC2
VITC2            .       14.00000    38.00000    38.00000    90.00000    88.00000        .           .        VITC2
ANPRO2           .           .           .           .           .           .       66.70000    36.30000    ANPRO2
VEGPRO2          .       99.00000    22.60000     5.90000     4.10000     3.00000        .           .        VEGPRO2
RBBAL2           .        3.00000        .           .           .           .           .           .        RBBAL2
FPLALOT2         .           .           .           .           .        1.00000        .           .        FPLALOT2
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                                         PAGE    60  -  84/127

              FCHIC2        FEGG2        FARREN2       FCODI 2       FSARD2        FMILK2        FCMILK2       FOIL2         24....1

NETREV         .65000-      3.54000-       .87000-      1.02000-      1.10000-       .66000-      2.58000-      1.20000-     NETREV
FINBAL2        .65000        .54000        .80000       1.02000       1.10000        .66000       2.58000       1.20000      FINBAL2
KCAL2       524.00000     658.00000     293.00000    1018.0000     1411.0000      295.00000    2295.0000     4010.0000       KCAL2
PROTE2       56.10000      52.10000      60.90000     153.10000      93.40000      15.90000     117.90000         .          PROTE2
FAT2         31.50000      46.40000       3.70000       5.80000     110.70000      22.70000     136.10000      543.00000     FAT2
CARBY2           .          3.60000          .             .           2.70000      22.70000     154.00000         .          CARBY2
CALCI2       43.00000     218.00000    1556.0000      193.00000    1606.0000      540.00000    3892.0000          .          CALCI2
IRON2         4.60000       9.30000       2.40000      11.60000      15.90000        .50000       3.20000         .          IRON2
VITA2        60.00000     505.00000          .             .         245.00000     180.00000    1635.0000          .          VITA2
THIA2          .25000        .42000        .03000        .31000        .10000        .18000       1.13000         .          THIA2
RIBO2          .49000     120.00000        .27000       2.31000        .76000        .82000       5.67000         .          RIBO2
NIAC2        29.70000        .20000      12.60000      11.60000      20.10000        .50000      18.00000         .          NIAC2
VITC2            .             .             .           .60000          .             .             .             .          VITC2
ANPRO2       56.10000      52.10000      60.90000     153.10000      93.00000      15.90000     117.90000         .          ANPRO2
ROBAL2           .             .             .             .             .             .             .          10.00000     ROBAL2
CMILK2           .             .             .             .             .           1.00000       1.00000         .          CMILK2
FCHALOT2      1.00000          .             .             .             .             .             .             .          FCHALOT2
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..MPSX-VIM7..  REGIONAL PLANNING MODEL. AZUA-DR                                              PAGE    61  -  84/127

              FSALT2        FTOMP2       FCOFF2       FCHEE2       FULT2        FCDC2        CORN133      CORN233      25....1

NETREV         .10000-      1.10000-     1.40000-     2.75000-     2.25000-     1.25000-    16.33000-    10.18000-     NETREV
FINBAL2        .10000       1.10000      1.40000      2.75000      2.25000      1.25000       .            .           FINBAL2
KCAL2           .         372.00000    254.00000   1175.0000     34.48000   2395.0000       .            .           KCAL2
PROTE2          .          15.40000     36.30000    113.40000     2.70000     20.00000      .            .           PROTE2
FAT2            .           1.80000       .         113.40000   367.40000    159.20000      .            .           FAT2
CARBY2          .          84.40000     27.20000      9.10000     1.80000   2626.0000       .            .           CARBY2
CALCI2       1148.0000    122.00000    136.00000   3175.0000     68.00000    426.00000      .            .           CALCI2
IRON2           .          15.90000      4.50000      4.50000      .           6.40000      .            .           IRON2
VITA2           .        1500.0000        .        1905.0000   4255.0000      60.00000      .            .           VITA2
THIA2           .            .88000       .            .05000      .            .11000      .            .           THIA2
RIBO2           .            .54000      .05000      2.04000      .            .64000      .            .           RIBO2
NIAC2           .          14.20000    122.50000      .50000      .           1.50000      .            .           NIAC2
VITC2           .         221.00000       .            .           .            .           .            .           VITC2
ANPRO2          .            .            .         113.40000     2.70000      .           .            .           ANPRO2
VEGPRO2         .           1.80000     36.30000      .           .          20.00000      .            .           VEGPRO2
FSALOI2        1.00000       .            .            .           .            .           .            .           FSALOI2
LANDA9          .            .            .            .           .            .          1.00000       .           LANDA9
LANDA10         .            .            .            .           .            .          1.00000       .           LANDA10
LANDA11         .            .            .            .           .            .          1.00000       .           LANDA11
LANDA12         .            .            .            .           .            .          1.00000       .           LANDA12
LANDB9          .            .            .            .           .            .           .           1.00000      LANDB9
LANDB10         .            .            .            .           .            .           .           1.00000      LANDB10
LANDB11         .            .            .            .           .            .           .           1.00000      LANDB11
LANDB12         .            .            .            .           .            .           .           1.00000      LANDB12
DECLAB          .            .            .            .           .            .           .90000       .98000      DECLAB
JANLAB          .            .            .            .           .            .          1.63000      1.68000      JANLAB
FEBLAB          .            .            .            .           .            .          1.08000      1.12000      FEBLAB
MARLAB          .            .            .            .           .            .          1.40000      1.45000      MARLAB
FINBAL3         .            .            .            .           .            .         16.33000     10.18000      FINBAL3
DCORN3          .            .            .            .           .            .          3.00000-     2.00000-     DCORN3
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-DR                                                    PAGE    62  -  84/127
             CORN213       SORG113       SORG123       SORG133       SORG233       RBEA113       RBEA123       PEP123       26.....1

NETREV      13.57000-     16.27000-     17.62000-     17.16000-     17.16000-     30.84000-     27.99000-     54.14000-    NETREV
LANDA9        .            1.00000       1.00000       1.00000        .            1.00000       1.00000       1.00000     LANDA9
LANDA10       .            1.00000       1.00000       1.00000        .            1.00000       1.00000       1.00000     LANDA10
LANDA11       .            1.00000       1.00000       1.00000        .            1.00000       1.00000       1.00000     LANDA11
LANDA12       .            1.00000       1.00000       1.00000        .             .             .            1.00000     LANDA12
LANDB9       1.00000        .             .             .            1.00000        .             .             .          LANDB9
LANDB10      1.00000        .             .             .            1.00000        .             .             .          LANDB10
LANDB11      1.00000        .             .             .            1.00000        .             .             .          LANDB11
LANDB12      1.00000        .             .             .            1.00000        .             .             .          LANDB12
RBAL013       .             .             .             .             .            1.00000       1.00000        .          RBAL013
PEAL013       .             .             .             .             .             .             .            1.00000     PEAL013
DECLAB        .86000        .36000        .37000        .29000        .31000       1.83000        .78000       2.28000     DECLAB
JANLAB       1.56000        .58000        .62000        .58000        .48000        .32000       1.18000       1.56000     JANLAB
FEBLAB       1.18000        .29000        .33000        .37000        .39000       1.13000       1.05000       1.53000     FEBLAB
MARLAB       1.37000        .98000        .94000        .89000        .76000        .             .            7.23000     MARLAB
FINBAL3     13.57000      16.27000      17.16000      17.16000      17.16000      30.82000      27.99000      52.19000     FINBAL3
DCORN3       2.50000-       .             .             .             .             .             .             .          DCORN3
DSORG3        .            3.38000-      3.88000-      4.00000-      4.00000-       .             .             .          DSORG3
DRBEA3        .             .             .             .             .            1.16000-      1.20000-       .          DRBEA3
DPEP3         .             .             .             .             .             .             .            9.76000-    DPEP3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DH                                                   PAGE    63  -  84/127

            PEP233      OKR123      OKR133      TOM133      TOM233      PEA133      PEA213      PEA233      27....1

NETREV      43.00000-   35.27000-   58.34000-   35.37000-   60.85000-   19.10000-   18.18000-       .       NETREV
LANDA9          .        1.00000     1.00000     1.00000        .        1.00000        .           .       LANDA9
LANDA10         .        1.00000     1.00000     1.00000        .        1.00000        .           .       LANDA10
LANDA11         .        1.00000     1.00000     1.00000        .        1.00000        .           .       LANDA11
LANDA12         .        1.00000     1.00000     1.00000        .        1.00000        .           .       LANDA12
LANDB9       1.00000        .           .           .        1.00000        .        1.00000        .       LANDB9
LANDB10      1.00000        .           .           .        1.00000        .        1.00000        .       LANDB10
LANDB11      1.00000        .           .           .        1.00000        .        1.00000     1.00000    LANDB11
LANDB12      1.00000        .           .           .        1.00000        .        1.00000     1.00000    LANDB12
PEALOT3      1.00000        .           .           .           .           .           .           .       PEALOT3
OKALOT3         .        1.00000     1.00000        .           .           .           .           .       OKALOT3
DECLAB       1.48000     2.28000     2.30000      .35000      .70000      .20000      .30000      .32000    DECLAB
JANLAB       1.89000      .89000      .78000     3.07000     2.98000      .89000      .58000     1.28000    JANLAB
FEBLAB       1.60000     1.86000     1.60000     1.79000     1.86000      .36000      .36000      .76000    FEBLAB
MARLAB       6.50000     3.25000     4.04000     3.14000     3.23000     2.00000     1.79000     2.10000    MARLAB
FINBAL3     43.00000    35.27000    38.24000    56.37000    60.85000    19.10000    18.18000    12.25000    FINBAL3
DPEP3       12.00000-       .           .           .           .           .           .           .       DPEP3
DOKR3           .        6.26000-   12.00000-       .           .           .           .           .       DOKR3
DTOM3           .           .           .       40.65000-   45.00000-       .           .           .       DTOM3
DPEA3           .           .           .           .           .        1.33000-    1.50000-     .97000-   DPEA3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                                        PAGE    64  -  84/127

               LHDEC         LHJAN         LHFEB         LHMAR         LSDEC         LSJAN         LSFEB         LSMAR         28....1

NETREV         4.00000-      4.00000-      4.00000-      4.00000-      4.00000       4.00000    .  4.00000       4.00000       NETREV
DECLAB         1.00000-       .             .             .            1.00000        .             .             .            DECLAB
JANLAB          .            1.00000-       .             .             .            1.00000        .             .            JANLAB
FEBLAB          .             .            1.00000-       .             .             .            1.00000        .            FEBLAB
MARLAB          .             .             .            1.00000-       .             .             .            1.00000       MARLAB
FINBAL3        4.00000       4.00000       4.00000       4.00000       4.00000-      4.00000-      4.00000-      4.00000-      FINBAL3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR                                              PAGE   65  -  84/127

           TRANCAP3    CAPINV3     SCORN3      SSORG3      SRICE3      SRBEA3      SPBEA3      SGAND3      25....1

NETREV        .           .         7.25000     6.30000    26.00000    38.05000    35.00000    18.00000   NETREV
CHSCORN       .           .         2.00000      .           .           .           .           .        CHSCORN
FINBAL3     1.00000       .           .          .           .           .           .           .        FINBAL3
CAPINV      1.12000-    1.00000     7.25000     6.30000    26.00000    38.50000    35.00000    18.00000   CAPINV
DCORN3        .           .         1.00000      .           .           .           .           .        DCORN3
DSORG3        .           .           .         1.00000      .           .           .           .        DSORG3
DRICE3        .           .           .          .          1.00000      .           .           .        DRICE3
DRBEA3        .           .           .          .           .          1.00000      .           .        DRBEA3
DBUEA3        .           .           .          .           .           .          1.00000      .        DBUEA3
DGAND3        .           .           .          .           .           .           .          1.00000   DGAND3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                          PAGE    66  -  84/127

             SPLAN3       SPEP3        SOKR3        STOM3        SPLA3        CCORN3       CRICE3       CRBEA3       30....1

NETREV       50.00000     10.00000     12.00000      2.00000     15.00000        .            .            .         NETREV
CAPINV       50.00000     10.00000     12.00000      2.00000     15.00000        .            .            .         CAPINV
DCORN3          .            .            .            .            .         1.00000         .            .         DCORN3
DRICE3          .            .            .            .            .            .         1.00000         .         DRICE3
DRBEA3          .            .            .            .            .            .            .         1.00000      DRBEA3
DPLAN3        1.00000        .            .            .            .            .            .            .         DPLAN3
DPEP3           .         1.00000         .            .            .            .            .            .         DPEP3
DOKR3           .            .         1.00000         .            .            .            .            .         DOKR3
DTOM3           .            .            .         1.00000         .            .            .            .         DTOM3
DPEA3           .            .            .            .         1.00000         .            .            .         DPEA3
KCAL3           .            .            .            .            .        165100.00    164700.00    152900.00    KCAL3
PROTE3          .            .            .            .            .        3580.0000    3040.0000    9900.0000    PROTE3
FAT3            .            .            .            .            .        540.00000    180.00000    730.00000    FAT3
CARBY3          .            .            .            .            .        33526.000    36470.000    25080.000    CARBY3
CALCI3          .            .            .            .            .        2700.0000    10500.000    39000.000    CALCI3
IRON3           .            .            .            .            .        500.00000    360.00000    3450.0000    IRON3
VITA3           .            .            .            .            .        20000.000        .        500.00000    VITA3
THIA3           .            .            .            .            .         64.00000     32.00000    245.00000    THIA3
RIBO3           .            .            .            .            .         23.00000     12.00000     86.00000    RIBO3
NIAC3           .            .            .            .            .        400.00000    720.00000    950.00000    NIAC3
VITC3           .            .            .            .            .            .            .        1400.0000    VITC3
VEGPRO3         .            .            .            .            .        3580.0000    3040.0000    9900.0000    VEGPRO3
RBBAL3          .            .            .            .            .            .         1.00000-        .         RBBAL3
ROBAL3          .            .            .            .            .            .         1.00000-        .         ROBAL3
FRALOT3         .            .            .            .            .            .         1.00000         .         FRALOT3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR                                                  PAGE    67  -  84/127

            CBBEA3       CGAND3       CPLAN3       CTOM3        CPEAN3       FRICE3       FPAST3       FCORN3       31....1

NETREV         .            .            .            .            .          .28000-      .28000-      .14000-     NETREV
FINBAL3        .            .            .            .            .          .28000       .32000       .14000      FINBAL3
DBBEA3      1.00000         .            .            .            .            .            .            .         DBBEA3
DGAND3         .         1.00000         .            .            .            .            .            .         DGAND3
DPLAN3         .            .         1.00000         .            .            .            .            .         DPLAN3
DTOM3          .            .            .         1.00000         .            .            .            .         DTOM3
DPEA3          .            .            .            .         1.00000         .            .            .         DPEA3
KCAL3       154700.00    152900.00    413000.00    9300.0000    255000.00    1647.0000    1674.0000    1651.0000    KCAL3
PROTE3      10903.000    8700.0000    3800.0000    360.00000    11790.000    30.40000     56.70000     35.58000     PROTE3
FAT3        540.00000    680.00000    300.00000    130.00000    21550.000    1.80000      5.54000      5.40000      FAT3
CARBY3      27530.000    28710.000    110500.00    2040.0000    8440.0000    364.70000    341.10000    355.60000    CARBY3
CALCI3      34900.000    62100.000    25000.000    3200.0000    26800.000    109.00000    122.00000    27.00000     CALCI3
IRON3       3270.0000    2270.0000    390000.00    2700.0000    910.00000    3.60000      5.90000      5.00000      IRON3
VITA3       2500.0000    2500.0000    220.00000    26500.000       .            .            .         200.00000    VITA3
THIA3       395.00000    327.00000    130.00000    27.00000     449.00000    .30000       .40000       .64000       THIA3
RIBO3       104.00000    77.00000     1600.0000    22.00000     59.00000     .10000       .30000       .23000       RIBO3
NIAC3       846.00000    1180.0000    68000.000    310.00000    7170.0000    .70000       .80000       4.00000      NIAC3
VITC3       1400.0000       .            .         10200.000       .            .            .            .         VITC3
VEGPRO3     10903.000    8710.0000    3800.0000    360.00000    11790.000    30.40000     56.70000     35.80000     VEGPRO3
RBBAL3         .            .            .            .            .         1.00000-        .            .         RBBAL3
RDBAL3         .            .            .            .            .         1.00000-        .            .         RDBAL3
FRALOT3        .            .            .            .            .         1.00000         .            .         FRALOT3
FPALOT3        .            .            .            .            .            .         1.00000         .         FPALOT3
FCALOT3        .            .            .            .            .            .            .         1.00000      FCALOT3
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..MPSX-VIN7..  REGIONAL  PLANNING  MODEL. AZUA-DR                                                          PAGE     68  -  84/127

              FUHEAD3        FSPOT3        FPOT3         FYUC3         FSUG3         FBEAN3        IGARL3        FONI3         32....1

NETREV          .36000-        .10000-       .17000-       .08000-       .18000-       .38000-      1.66000-       .30000-     NETREV
FINDAL3         .36000         .10000        .17000        .17000        .18000        .38000       1.46000        .30000      FINDAL3
KCAL3         1220.0000      440.00000     316.00000     493.00000     1746.0000     1529.0000     549.00000     169.00000     KCAL3
PROTE3          39.50000       4.90000       7.70000       4.10000        .            99.00000      22.60000       5.90000     PROTE3
FAT3            14.50000       1.50000        .40000       1.00000        .             7.30000        .90000        .80000     FAT3
CAHBY3         228.00000     103.20000      73.30000     119.40000     451.30000     258.00000     129.00000      38.00000     CAHBY3
CALCI3           3.18000     128.90000      31.00000     112.00000        .           390.00000     162.00000     135.00000     CALCI3
IRON3            3.20000       3.00000       2.70000       2.40000        .            34.50000       6.00000       2.10000     IRON3
VITA3             .           40.00000        .             .             .             5.00000       5.00000       5.00000     VITA3
THIA3             .31000        .38000        .39000        .20000        .             2.45000        .90000        .13000     THIA3
RIBO3             .36000        .19000        .12000        .10000        .              .86000        .34000        .17000     RIBO3
NIAC3            5.00000       2.30000       5.40000       2.00000        .             9.50000       2.60000        .80000     NIAC3
VITC3             .           87.00000      39.00000     122.00000        .            14.00000      38.00000      38.00000     VITC3
VEGPRO3         39.50000       4.90000       7.70000       4.10000        .            99.00000      22.60000       5.90000     VEGPRO3
RDBAL3            .             .             .             .             .             3.00000        .             .          RDBAL3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR                                                      PAGE   69  -  84/127

              FBAN3        FPLAN3       FBEEF3       FPORK3       FCHIC3       FEGG3        FARHEN3      FCODF3       33....1

NETREV         .09000-      .10000-      .80000-      .73000-      .65000-     3.54000-      .87000-     1.02000-    NETREV
FINBAL3        .10000       .10000       .80000       .70000       .65000       .54000       .80000      1.02000     FINBAL3
KCAL3       359.00000    413.00000    1021.0000    197.70000    524.00000    658.00000    293.00000    1018.0000     KCAL3
PROTE3        4.10000      3.80000     66.70000     36.30000     56.10000     52.10000     60.90000    153.10000     PROTE3
FAT3           .60000       .30000     83.00000    185.20000     31.50000     46.40000      3.70000      5.80000     FAT3
CARBY3       83.30000    110.50000     .             .20000      .             3.60000      .            .           CARBY3
CALCI3       23.00000     25.00000     38.00000     21.00000     43.00000    218.00000    1556.0000    193.00000     CALCI3
IRON3         2.50000      2.50000      8.00000      5.30000      4.60000      9.30000      2.40000     11.60000     IRON3
VITA3         2.75000    390.00000     40.00000      .30000     60.00000    505.00000      .            .           VITA3
THIA3          .12000       .22000       .23000     11.77000       .25000       .42000       .03000       .31000     THIA3
RIBO3          .06000       .13000     40.00000       .42000       .49000    120.00000       .27000      2.31000     RIBO3
NIAC3         1.70000      1.60000     14.10000      9.40000     29.70000       .20000     12.60000     11.60000     NIAC3
VITC3        90.00000     88.00000     .            .            .            .            .             .60000     VITC3
ANPRO3         .            .          66.70000     36.30000     56.10000     52.10000     60.90000    151.10000     ANPRO3
VEGPRO3       4.10000      3.80000     .            .            .            .            .            .           VEGPRO3
FPLALOT3       .           1.00000     .            .            .            .            .            .           FPLALOT3
FCHALOT3       .            .          .            .            1.00000      .            .            .           FCHALOT3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL, AZUA-DR                                                 PAGE    70  -  84/127

              FSARD3       FMILK3       FDMILK3      FOIL3        FSALT3       FTOMP3       FCOFF3       FCHEE3       34.....I

NETREV        1.10000-      .66000-     2.50000-     1.20000-      .10000-     1.10000-     1.40000-     2.75000-     NETREV
FINBAL3       1.10000       .66000      2.58000      1.20000       .10000      1.10000      1.40000      2.75000      FINBAL3
KCAL3         1411.0000     295.00000   2295.0000    4010.0000      .          372.00000    254.00000    1175.0000    KCAL3
PROTE3        93.40000      15.90000    117.90000     .             .          15.40000     36.30000     113.40000    PROTE3
FAT3          110.70000     22.70000    136.10000    543.00000      .          1.80000       .           113.40000    FAT3
CARBY3        2.70000       22.70000    154.00000     .             .          84.40000     27.20000     9.10000      CARBY3
CALCI3        1606.0000     540.00000   3892.0000     .            1148.0000   122.00000    136.00000    3175.0000    CALCI3
IRON3         15.90000      .50000      3.20000       .             .          15.90000     4.50000      4.50000      IRON3
VITA3         245.00000     180.00000   1635.0000     .             .          1500.0000     .           1905.0000    VITA3
THIA3          .10000       .18000      1.13000       .             .           .88000       .            .05000      THIA3
RIBO3          .76000       .82000      5.67000       .             .           .54000      .05000      2.04000      RIBO3
NIAC3         20.10000      .50000      10.00000      .             .          14.20000     122.50000     .50000      NIAC3
VITC3          .             .            .           .             .          221.00000     .            .           VITC3
ANPRO3        93.00000      15.90000    117.90000     .             .           .            .           113.40000    ANPRO3
VEGPRO3        .             .            .           .             .          1.80000      36.30000      .           VEGPRO3
ROBAL3         .             .            .          10.00000       .           .            .            .           ROBAL3
CMILK3         .            1.00000     1.00000       .             .           .            .            .           CMILK3
FSALOT3        .             .            .           .            1.00000      .            .            .           FSALOT3
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..MPSX-VIN7..  REGIONAL PLANNING MODEL. AZUA-DR                                                     PAGE    71  -  84/127
                                                                                                                   35....1
              FBUT3         FCUC3         RHS2          CHCAPBOR

 NETREV       2.25000-      1.25000-          .             .           NETREV
 LANDA1          .             .          256987.00         .           LANDA1
 LANDA2          .             .          256987.00         .           LANDA2
 LANDA3          .             .          256987.00         .           LANDA3
 LANDA4          .             .          256987.00         .           LANDA4
 LANDB1          .             .          99939.000         .           LANDB1
 LANDB2          .             .          99939.000         .           LANDB2
 LANDB3          .             .          99939.000         .           LANDB3
 LANDB4          .             .          99939.000         .           LANDB4
 COALOT1         .             .          35000.000         .           COALOT1
 SOALOT1         .             .          25000.000         .           SOALOT1
 RALOT1          .             .          12000.000         .           RALOT1
 RBALOT1         .             .          25000.000         .           RBALOT1
 BDALOT1         .             .          18000.000         .           BDALOT1
 PLALOT1         .             .          15000.000         .           PLALOT1
 YUALOT1         .             .          8000.0000         .           YUALOT1
 PEALOT1         .             .          18000.000         .           PEALOT1
 OKALOT1         .             .          18000.000         .           OKALOT1
 IOMALOT1        .             .          43123.000         .           IOMALOT1
 OKRALOT1        .             .          18320.000         .           OKRALOT1
 MEALCT1         .             .          22000.000         .           MEALCT1
 APRILAB         .             .          245355.00         .           APRILAB
 MAYLAB          .             .          245355.00         .           MAYLAB
 JUNLAB          .             .          245355.00         .           JUNLAB
 JULLAB          .             .          245355.00         .           JULLAB
 FINBAL          .             .          4283112.0         .           FINBAL
 CAPBOR          .             .          9993928.0     500000.00       CAPBOR
 KCAL            .             .          .6424E+10         .           KCAL
 PROTE           .             .          .1475E+09         .           PROTE
 FAT             .             .          .1820E+09         .           FAT
 CARBY           .             .          .1158E+10         .           CARBY
 CALCI           .             .          .1585E+10         .           CALCI
 IRON            .             .          52153700.         .           IRON
 VITA            .             .          .2919E+10         .           VITA
 THIA            .             .          3318584.0         .           THIA
 RIBO            .             .          2971026.0         .           RIBO
 NIAC            .             .          32841882.         .           NIAC
 VITC            .             .          50432497.         .           VITC
 ANPRO           .             .          56208600.         .           ANPRO
 VEGPRO          .             .          91399124.         .           VEGPRO
 FRALOT1         .             .          1070640.0         .           FRALOT1
 FPALOT1.        .             .          223050.00         .           FPALOT1
 FCALOT1         .             .          669150.00         .           FCALOT1
 FPLALOT1        .             .          1784400.0         .           FPLALOT1
 FCHALOT1        .             .          334575.00         .           FCHALOT1.
 FSALOT1         .             .          44610.000         .           FSALOT1
 LANDA5          .             .          256987.00         .           LANDA5
 LANDA6          .             .          256987.00         .           LANDA6
 LANDA7          .             .          256987.00         .           LANDA7
  ANDA8          .             .          256987.00         .           LANDA8
  ANDB5          .             .          99939.000         .           LANDB5
  ANDB6          .             .          99939.000         .           LANDB6
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..MPSX-VIM7..  REGIONAL PLANNING MODEL, AZUA-CH                                              PAGE    72  -  84/127
              FOUT3        FCOC3        RHS2         CHCAPBOR                                                    35....2

  LANDB7        .            .         99939.000        .         LANDB7
  LANDB8        .            .         99939.000        .         LANDB8
  COALOT2       .            .         35000.000        .         COALOT2
  SOALOT2       .            .         25000.000        .         SOALOT2
  RALOT2        .            .         12000.000        .         RALOT2
  RBALOT2       .            .         25000.000        .         RBALOT2
  BOALOT2       .            .         18000.000        .         BOALOT2
  PEALOT2       .            .         19000.000        .         PEALOT2
  PEPALOT2      .            .         22253.000        .         PEPALOT2
  UNALOT2       .            .         8000.0000        .         UNALOT2
  ONIALOT2      .            .         29000.000        .         ONIALOT2
  OKALOT2       .            .         18000.000        .         OKALOT2
  OKRALOT2      .            .         18320.000        .         OKRALOT2
  MEALOT2       .            .         22000.000        .         MEALOT2
  AUGLAB        .            .         245355.00        .         AUGLAB
  SEPLAB        .            .         245355.00        .         SEPLAB
  OCTLAB        .            .         245355.00        .         OCTLAB
  NOVLAB        .            .         245355.00        .         NOVLAB
  KCAL2         .            .         .6424E+10        .         KCAL2
  PROTE2        .            .         .1475E+05        .         PROTE2
  FAT2          .            .         .1820E+09        .         FAT2
  CARBY2        .            .         .1158E+10        .         CARBY2
  CALC12        .            .         .1585E+10        .         CALC12
  IRON2         .            .         52193700.        .         IRON2
  VITA2         .            .         .2919E+10        .         VITA2
  THIA2         .            .         3318584.0        .         THIA2
  RIBO2         .            .         2971026.0        .         RIBO2
  NIAC2         .            .         32841882.        .         NIAC2
  VITC2         .            .         50432497.        .         VITC2
  ANPRO2        .            .         56208600.        .         ANPRO2
  VEGPRO2       .            .         91399124.        .         VEGPRO2
  FRALOT2       .            .         1070640.0        .         FRALOT2
  FPALOT2       .            .         223050.00        .         FPALOT2
  FCALOT2       .            .         669150.00        .         FCALOT2
  FPLALOT2      .            .         1784400.0        .         FPLALOT2
  FCHALOT2      .            .         334575.00        .         FCHALOT2
  FSALOT2       .            .         44610.000        .         FSALOT2
  LANDA9        .            .         256987.00        .         LANDA9
  LANDA10       .            .         256987.00        .         LANDA10
  LANDA11       .            .         256987.00        .         LANDA11
  LANDA12       .            .         256987.00        .         LANDA12
  LANDB9        .            .         99939.000        .         LANDB9
  LANDB10       .            .         99939.000        .         LANDB10
  LANDB11       .            .         99939.000        .         LANDB11
  LANDB12       .            .         99939.000        .         LANDB12
  RBALOT3       .            .         25000.000        .         RBALOT3
  PEALOT3       .            .         18000.000        .         PEALOT3
  OKALOT3       .            .         18000.000        .         OKALOT3
  DECLAB        .            .         245355.00        .         DECLAB
  JANLAB        .            .         245355.00        .         JANLAB
  FEBLAB        .            .         245355.00        .         FEBLAB
  MARLAB        .            .         245355.00        .         MARLAB
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..MPSX-VIM7..  REGIONAL  PLANNING  MODEL.  AZUA-DR                                              PAGE    73  -  84/127
              FOUT3          FCOC3          RHS2          CHCAPBOR                                                   35....3

FINBAL3      2.25000        1.25000          .               .            FINBAL3
CAPINV          .              .        4283112.0            .            CAPINV
KCAL3       34.48000     2395.0000      .6424E+10            .            KCAL3
PROTE3       2.70000      20.00000      .1475E+09            .            PROTE3
FAT3       367.40000     159.20000      .1820E+09            .            FAT3
CARBY3       1.80000     2626.0000      .1158E+10            .            CARBY3
CALCI3      68.00000     426.00000      .1585E+10            .            CALCI3
IRON3           .          6.40000      52193700.            .            IRON3
VITA3      4355.0000      60.00000      .2919E+10            .            VITA3
THIA3           .           .11000      3318984.0            .            THIA3
RIBO3           .           .64000      2971026.0            .            RIBO3
NIAC3           .          1.50000      32841882.            .            NIAC3
VITC3           .              .        50432497.            .            VITC3
ANPRO3       2.70000           .        56208600.            .            ANPRO3
VEGPRO3         .         20.00000      91399124.            .            VEGPRO3
FHALOT3         .              .        1070640.0            .            FHALOT3
FPALOT3         .              .        223050.00            .            FPALOT3
FCALOT3         .              .        669150.00            .            FCALOT3
FPLALOT3        .              .        1784400.0            .            FPLALOT3
FCHALOT3        .              .        334575.00            .            FCHALOT3
FSALOT3         .              .        44610.000            .            FSALOT3
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APPENDIX G

LABOR HIRED AND SOLD FOR THE OPTIMUM PLANS, AZUA, DOMINICAN REPUBLIC, 1984

Month	Labor in Farm-Household Plan						Labor in Regional Plan	
	25 tareas		60 tareas		125 tareas			
	hired	sold	hired	sold	hired	sold	hired	sold
April	-	0.35	10.77	-	70.50	-	180219	-
May	-	23.30	27.97	-	114.86	-	99963	-
June	-	24.56	-	17.20	31.32	-	67613	-
July	10.79	-	64.36	-	220.79	-	291636	-
August	-	25.39	7.36	-	92.34	-	112137	-
September	-	21.90	8.95	-	67.00	-	42829	-
October	-	13.03	5.21	-	84.65	-	-	9392
November	15.66	-	49.21	-	294.58	-	286935	-
December	-	14.23	111.43	-	135.60	-	-	4866
January	-	2.25	-	16.79	98.80	-	44537	-
February	-	24.21	0.39	-	77.57	-	45519	-
March	13.12	-	85.37	-	251.68	-	288150	-

BIOGRAPHICAL SKETCH

The author was born on January 29, 1946, in San Cristobal, Dominican Republic. Shortly afterwards he moved to Santo Domingo, where he attended elementary school. In 1972 he received the degree of Licenciado en Economia from the department of Economics at the Autonomous University of Santo Domingo. In 1974 he received his Master of Arts degree in economics at Vanderbilt University, Nashville, Tennessee.

During the period 1975-1978 he worked at the Secretariat of State for Agriculture as head of the Agricultural Marketing Division and later he became head of the Economics Research Division.

Since 1975, the author also held a part-time teaching position at the Department of Mathematics at the Autonomous University of Santo Domingo, and at the Department of Economics at the Catholic University in Santo Domingo.

In 1979, he was selected by the Secretariat of Agriculture to pursue doctoral studies at the University of Florida, Gainesville, Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Gustavo A. Antonini, Chairman
Professor of Geography and Latin
American Studies

I certify that I have read this study and that in my opninion it conforms to acceptable standards of scholarly presentation and is fully adequate,.in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Peter E. Hildebrand
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate,.in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

David Mulkey

William D. Mulkey
Associate Professor of Food and
Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate,.in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Caviedes

Cesar N. Caviedes
Professor of Geography

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Geography in the College of Liberal Arts and Sciences and to the Graduate School, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1984

Dean for Graduate Studies and Research